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Forthcoming Events.

JULY 4 to 9.
Society of Chemical Industry:—Forty-sixth annual meeting to be held in Edinburgh.

JULY 5-8.
Institute of British Foundrymen.
Conference at Sheffield.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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The Industry and Patents.

The British patent system is in some respects the most curious in the world. The unwritten laws of the Patent Office, like the unwritten laws of the British Constitution, are much more important than the written code, and the interpretation of patent law in the courts is largely a matter of equity and common sense.

Ironfounding being an ancient craft, there are very few patents of any consequence in the industry, and we suggest that the industry could with advantage pursue a patent policy much more enterprising that has been possible in the past, such a policy, for instance, as that pursued by the steel industry. This could be done both by individual manufacturers and by the co-operative research and trade associations in the industry, for a far-seeing patent policy has valuable commercial advantages independent of any technical achievements embodied in the specifications themselves.

Nothing but benefit to the industry as a whole can come from the stimulus offered by the existence of a few patents. There is no discredit attaching to a manufacturer who may find it necessary to take out a licence to work a patent owned by someone else. In fact, there are well-known cases of progressive licensees who were able to dictate to the inventor at the expiry of the life of a patent on account of improvements of their own. On the whole we believe that the British manufacturer is of that sporting type which will fully recognise a patent owned by somebody else. Further, as a rule, he would go a long way out of his way to avoid anything in the nature of litigation. As a consequence there are many patents of doubtful technical validity which remain unchallenged.

At the same time, however, the British manufacturer has a very keen sense of what is fair, and if made to feel that he is being mulcted unduly he will strain every nerve to overcome the obstacle in some other way. The patent law was originally framed to take care of developments of the nature of improvements in mechanism, and in this sense it is still applicable, for example, to improvements in moulding machines. With the rapid advance of science and its application to industry, improvements become possible that are due to discovery rather than invention, and, strictly speaking, no patent can be taken out for a discovery, that is, a contribution to knowledge. A patentable idea should result in some new contrivance, new material, or new method of industrial procedure which is an improvement in the state of the art, and for the disclosure of which in the specification a monopoly is granted for a number of years. It is, however, possible in various ways to secure patents for what are in fact discoveries. Here, again, many such only remain valid as long as they are unchallenged, and probably would not survive an action in the courts.

All this suggests that patentees should be more rather than less willing to meet prospective licensees on an equitable basis. We think, therefore, that those who have new methods or materials to offer the industry should seriously consider not how much can be got when there is already too little margin for development, but rather how easy they can make it for the whole of the industry to adopt the new idea. A small fee for a non-exclusive licence might realise more in the aggregate than a large fee for a similar licence that can only be taken out by a few of those interested. There can be no question as to which condition is better for the industry as a whole.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

Estimating Carbon by Combustion.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—We find pleasure in answering the question raised by "Works Chemist" in your issue dated June 23, with reference to the methods we have adopted for estimating carbon by combustion, and reply as follows to the points raised:—

(1) *Using Lead Chromate.*—We use lead chromate of the special carbon free fused powder; then it is not necessary to use a definite weight, but we vary the quantity according to the state of the drillings. Perhaps "Works Chemist" has taken a slight furnace blank as being due to lead chromate.

(2) *Time Required.*—Furnace temperature is 1,000 deg. C., and the oxygen is run through at a rapid rate. When the material commences to take up oxygen, the speed is increased and the oxygen put through vigorously until complete combustion has taken place. The oxygen is then cut off a little and another six or seven minutes is sufficient to sweep out the combustion train. Another run of boats are usually put in immediately, and the temperature is not allowed to fall at all or the speed of combustion cannot be kept up. The weight taken of an ordinary steel sample is 2.727 grs., and of a cast iron 1.363 grs. Special bulbs are in use with the combustion train, as if such was not the case the liquid would splash over from the chromic and sulphuric acid bulbs, causing the rubber connections to perish, which, as every chemist knows, will mean high results on carbon estimations. If the ordinary Arnold type bulb is used then spraying occurs, but with our special Carbest bulbs no spraying whatever takes place. If "Works Chemist" would like to communicate with us direct, we shall be very pleased to supply him with a fuller description and lay-out of our own combustion train.

We have also read with interest in your issue of June 30 a point raised by "Another Works Chemist." We would state that Carbest is the name given to the type of bulbs we use, also to the special absorbent which is used for the CO_2. The combustion boats are made of special clay of a suitable size, and we would also ask "Another Works Chemist" to send for a full description of our own train, when we shall be pleased to send him same with the greatest of pleasure. No doubt he will find that whilst a word of two in a descriptive article might be misleading, he will find the leaflets which we issue on the materials to be used for estimating carbon by combustion are quite clear. It might also be interesting to learn that many steel works of all sizes in Great Britain, America, and on the Continent have adopted this special train, using the special type bulb as well as our Carbest absorbent.—Yours, etc.,

F. WOOD, Chief Chemist
(Beecroft & Partners, Limited, St. Peter's Close, Sheffield).

July 2, 1927.

Progress in Ironfounding.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Mr. Shaw, in his letter in this week's issue, states that he dissociates himself from much in my letter in the previous issue, but by inference he only disagrees with one of the *five* points raised by me yet, in this one point he does not endorse all the claims the Germans have made. The one point which Mr. Shaw does not endorse is a statement of fact by a practical ironfounder of as wide experience and equal reputation to Mr. Shaw, hence I have nothing further to add.

There is not the smallest wish on my part, to belittle the work of Herr Sipp and his colleagues, but one naturally asks if it is of such great importance why has their experience—presumably embodied in the Perlit process—not been more adopted? Mr. Shaw's letter gives the necessary answer: "The trouble is that no unbiassed trial has been made under working conditions, to prove definitely what is to be gained." That was the whole point of Mr. Shaw's letter, in your issue of June 9.

My object in raising the point, which Mr. Shaw apparently does not endorse, is that credit should be given where credit is due, even if it has to go to our own countrymen.

Yours, etc.,
E. ADAMSON.

18, York St., Sheffield.
July 1, 1927.

[This correspondence must now close.—EDITOR.]

Electric Furnace Industry.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—Your leader on the electric Furnace industry in the current issue of the "F.T.J." is of great interest.

There is, as you say, no reason why the voltage of electric melting furnaces should not have a higher value than obtains in many installations. Our own practice is 200 volts per phase in 10 to 15-ton furnaces,120 volts in the 3-ton size, and 105 volts in the 1½-ton size. Additionally to the quickened speed of melting which results from such voltages, the power factor of the furnace is higher, for reasons electrical engineers will appreciate.

There is, as you further suggest, no difficulty in arranging large electric furnaces for machine charging, and we have very successfully installed plant for such charging.

It is undoubtedly true that cast iron from an electric furnace is stronger than cupola metal. We have cast considerable quantities by both processes at these works and could rely on four to six tons higher tensile resistance per square inch in the electrically treated material. We believe this is entirely due to the greater freedom of the iron from gases in solution and in combination.—Yours, etc.,

THE STOBIE STEEL COMPANY,
Per M. R. COMPSTON.

Dunston-on-Tyne, July 4, 1927.

Foundry Query.

Exhausting Grinding Wheel Dust.

H.M. Inspector of Factories has some new regulation with regard to exhausting dust away from emery wheels and tumblers. Can you give me any information on this matter? I have several pairs of emery wheels which are used intermittently, and if I have to fix an exhauster to each of these and to the tumblers, I am in for a great expense. If they were all in one shop it would be comparatively easy to deal with them, but they are somewhat isolated. Any information you can give me on this matter will be gratefully received.—FOUNDRY OWNER.

Catalogues Received.

Cast-Iron Pipes.—The stock list issued by the Stanton Iron Works Company, Limited, for June is now available.

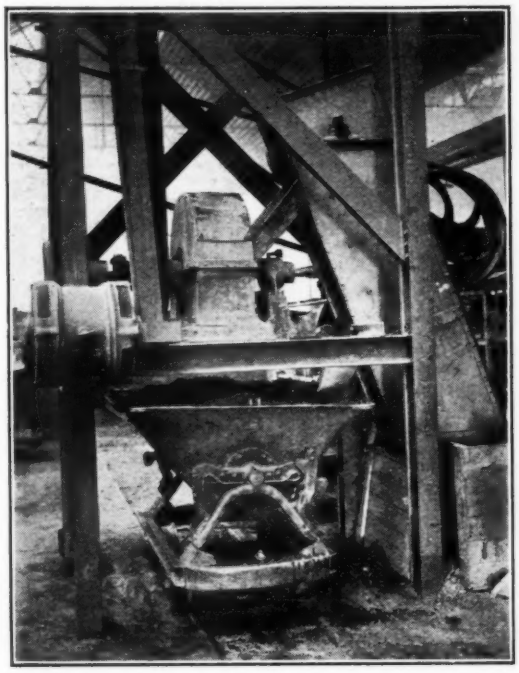
Laboratory Apparatus.—Many bargains are described and illustrated in a list issued by Messrs. Ogilvy & Company, of 20, Mortimer Street, London, W.1. These relate mainly to microscopes of various types and their accessories. Foundrymen requiring either additional apparatus or spare parts would do well to furnish themselves with this catalogue.

Disintegrators and Mixers.—W. Brearley & Company, Limited, Prospect Works, Hawksley Avenue, Sheffield, have sent us a catalogue of their "Breakir" (improved Carr type) disintegrator and mixer, describing their single type sand mixing machine for foundries.

MR. R. LESLIE HUNTER, B.Sc., A.M.I.Mech.E., assistant works manager to M. Cockburn & Company, Limited, Falkirk, and Monument Station Buildings, London, E.C., was the recipient from his colleagues of a silver tea service as a token of their esteem, on the occasion of his wedding to Miss Doris Hulme, of New Zealand. After taking his B.Sc., Mr. Hunter served his apprenticeship with Babcock & Wilcox, boiler makers and engineers, Renfrew. Having completed that course he visited America where he worked in various foundries and engineering shops throughout that country.

Sand-Disintegrator Plant.

The effective inclusion of standard plant in foundry transport systems is shown to advantage in our illustration, which shows a 28-in. double type cage "Breakir" sand disintegrator installed in the Farringdon steel foundry of Leyland Motors, Limited, of Leyland, Lancashire. This



A "BREAKIR" DISINTEGRATOR PLANT INSTALLED IN THE FARRINGDON STEEL FOUNDRY OF LEYLAND MOTORS, LIMITED.

plant is made by Messrs. W. Brealey & Company, Limited, of Prospect Works, Hawksley Avenue, Hillsborough, Sheffield. These machines, it will be remembered, are driven by two belts running in opposite directions. One of these drives the shaft and the other the sleeve which revolves round the shaft. Keyed to both shaft and sleeve are bosses carrying the steel cage plates, to which in turn are attached the reels or cages driven by the shaft intermeshing with those driven by the sleeve, each cage containing a number of evenly-spaced bars or spindles.

It is interesting to note that there are now going through the shops a large batch of 40-in. machines for treating foundry sand at the quarries, in order to deliver it in better condition for immediate use.

Mould Conveyors.

Mr. A. S. Beech, of Belmont, Lichfield Road, Four Oaks, in a recently published Patent Specification (No. 270,904), describes an apparatus designed to overcome the breakage of moulds and their cores during the passage along gravity conveyors. This is accomplished by providing evenly spaced movable triggers, which are carried on mechanically actuated supports. When these are upstanding the moulds are arrested and prevented from running into each other.

The method is shown in Fig. 1, which shows the arrangement to consist of a framework a, a^1, and cross supports a^2, the whole normally being inclined as shown. In this framework there are mounted a series of rollers "b," and also a number of longitudinal shafts "c" placed below the rollers and supported in bearings c^1c^1. These shafts are provided with gears d^1d^1 at the upper ends, interconnected by wheel d^1 and are rotatable by the crank d^2. Upon these shafts there are mounted the triggers "e," which when up arrest and suitably separate the moulds from each other. When down the moulds proceed on their journey. The fingers are provided with anti-friction rollers so as to minimise the force of impact.

Founders are always pleased to note any development in transport systems, as they realise that this is the most fertile field for reduction of overhead costs. Every foundry manager would be well advised constantly to bear in mind the saying that 100 tons of material has to be moved to manufacture one ton of castings.

Broughton Copper Company, Limited.—Profit, £41,067; brought in, £10,032; less debenture interest, interest on loans, interim dividend on preference, and interim dividend on ordinary; available, £30,562; reserve account, £2,000; final dividend, 10 per cent. on ordinary, making 15 per cent. for year, less tax; carried forward, £2,212.

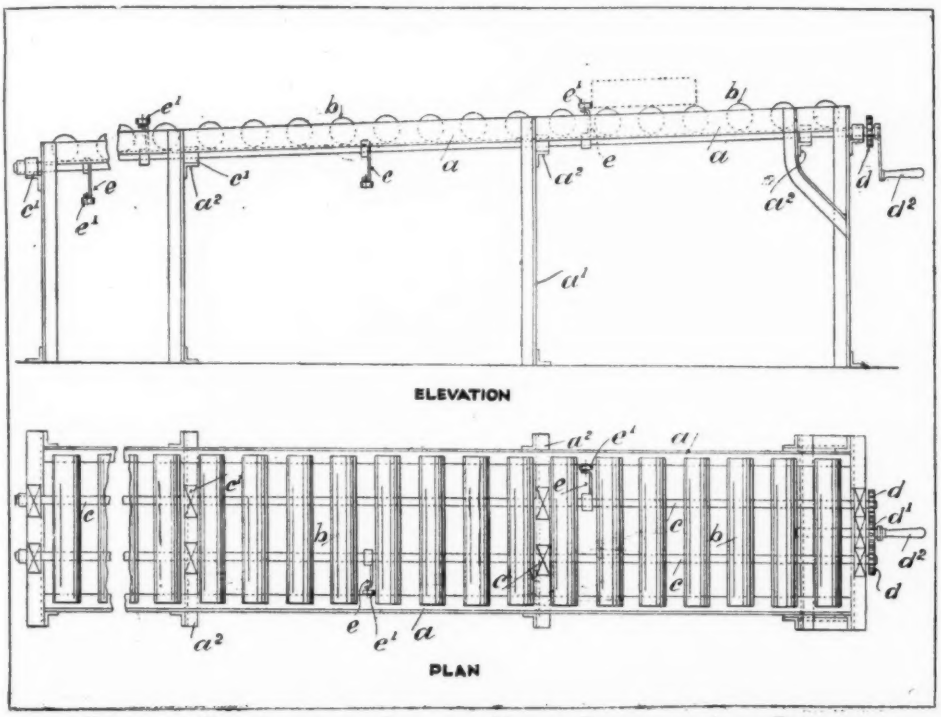


FIG. 1.—A NEW SYSTEM FOR CONVEYING MOULDS DESIGNED TO AVOID BUMPING.

On the Effect of Nickel and Chromium on the Strength Properties of Grey Cast Iron.*

By Professor E. PIWOWARSKY, Dr.Eng., Aix-la-Chapelle.

A fairly extensive literature already exists on the effect of nickel and chromium additions on the properties of cast iron.[1] From these works, and also from the reports and communications of numerous manufacturing and consuming concerns, it is apparent that even a nickel addition of from 0.5 to 3.0 per cent. appreciably increases the uniformity and density of the structure, ensures very good machinability even in hard types of iron, prevents the appearance of hard spots, and increases the resistance to corrosion and wear, etc. It is also known that a moderate addition of chromium in cast iron with a nickel content has a particularly beneficial effect in improving the structure and increasing the resistance to wear and the liability to "grow." Most of these chemico-metallurgical and physical advantages are present—and far too little regard is paid to this fact—even when the mechanical test shows scarcely any, or only a moderate increase in the strength figures. In point of fact, indeed, the increase of strength found by numerous investigators (Campion, Hurst, Moldenke, Piwowarsky and Baver, Smalley, Merica, Wickenden, Vanick, etc.) in pearlitic cast iron as a result of alloying with nickel and chromium, as a rule hardly exceeds 30 per cent. So long, therefore, as the mechanical properties obtained by alloying do not exceed these limits, which are such as can be obtained in unalloyed cast iron by suitably mixing the charge and by paying regard to the more recent refining processes (*e.g.*, abnormal superheating of the liquid iron[2]), there is obviously no occasion to add nickel and chromium to the metal merely for the purpose of increasing its strength. Moreover, it is by no means certain at present whether the results so far obtained in increasing the mechanical properties of cast iron by nickel and chromium additions may not be mainly attributable to causes which—as, for example, the refinement of the graphite—could be obtained by cheaper and simpler means (deoxidation, superheating the molten metal, etc.). It appeared necessary, therefore, to investigate the influence of these two most important alloying elements, which unquestionably operate beneficially in regard to their physico-metallurgical reaction, on cast iron to which the best mechanical qualities, as far as technical judgment could anticipate, had been imparted by suitable treatment.

The course was therefore adopted of bringing very hot molten iron to a state of solidification, at first mainly white, and of graphitising it only by subsequent annealing so that it contained:—(1) The primary carbon in the finest and most favourable arrangement possible, and (2) as fine-grained a sorbitic-pearlite ground mass as possible.

At the same time it was intended to pay special attention to the effect of nickel and chromium on the thermal stability of the metal. The charge of the melts had, therefore, to be adjusted so that by accelerated solidification and cooling the iron solidified preponderatingly white, but nevertheless contained sufficient silicon to render probable the complete dissociation of the hyper-eutectic carbon by means of as short as possible a subsequent annealing at not too high a temperature, for a long period of annealing, particularly at too high a temperature, might possibly have eliminated again the advantages of the fine primary structure. It was necessary, however, that the silicon content should not be so high as to permit of large quantities of ferrite making their appearance during the cooling when the annealing had been effected. This could be secured if a grey to mottled charge were caused to solidify mottled to grey by artificially accelerated cooling.

For the tests in question two main series of experiments were arranged, viz., one with high carbon and low silicon iron (indicated by A), and one with low carbon and high silicon metal (indicated by B).

Within these two series heats were carried out without nickel, as well as heats which were adjusted to 1 and 3 per cent. nickel and 3 per cent. nickel + 0.5 per cent chromium in the final product. A charge of German hematite and ingot iron (dead mild steel) was used as raw material in all the heats. About 10 per cent. of Swedish pig-iron was used in the charge of heat 1 only. The increase of the silicon addition in series B was effected by adding high percentage ferro-silicon to the finished heat. The weight of all the casts in the tests was about 25 kg. (55 lbs.). They were carried out in a graphite crucible lined with magnesite, and in an oil-heated furnace. The temperature of the heat was in all cases raised to about 1,550 deg. C., when the crucible was taken out of the furnace, and the heat poured when the temperature had fallen to 1,400 deg. The temperature was measured optically (by the Holborn-Kurlbaum pyrometer) and by inserting platinum and platinum-rhodium thermo-elements in the heats to check the measurements. From each heat four test bars about 33 mm. in diameter and 700 mm. in length were cast, two of these being poured into an iron chill, lined fairly thickly with clay, which was in each case preheated to 100 deg. The last two bars were cast in a dry sand mould.[3] Top casting was employed throughout. The bars cast in chills were rapidly heated in a gas muffle furnace to about 925 to 950 deg. C. As soon as they had reached this temperature the furnace was shut off and the samples were left to cool. Half of these chill bars were thereupon reheated to 20 to 30 deg. above the A_3 point and quenched in oil. The hardening temperature varied, according to the composition of the samples, from 820 to 850 deg. The quenched samples were kept at 650 deg. for half an hour, when they were again quenched in oil; they were then reheated to 450 deg. for 15 minutes for the removal of any hardness stresses, and then left to cool.

For mechanical testing all the bars were turned to a diameter of 30 mm. The results of the research are summarised in Table 1. These show that as a result of the thermal and melting process here employed unusually high bending strengths were in fact attained. These might possibly have been even higher if more care had been devoted to the process of deoxidation and to overcoming the occurrence of piping, to which further reference is made later. Series of tests on this point are in preparation. It should be noted that very high deflection values are peculiar to high transverse strengths. When it is considered that in the normal transverse test, with a bar diameter of 30 mm. and a distance between the supports equal to 20 times the diameter, deflections of 10 to 15 mm. are usual and normal, the deflection values of 20 to about 45 mm. must be characterised as exceptionally high. They demonstrate the great toughness[4] and elasticity of the material. In these tests, unfortunately, it was not as yet possible, as has already been stated, entirely to eliminate the piping favoured by the white or mottled solidification and the large diameter of the bars. Suitable signs are accordingly inserted in column 5 of Table 1 to indicate whether the fracture was found faultless, or showed a slight or a serious pipe. When it is considered that only a few of the values are indicated

* A Paper read before the Sheffield Convention of the Institute of British Foundrymen on behalf of the German Foundry Industry.

[1] *Cf.* the bibliography in the Bulletin of the British Cast Iron Research Association, No. 8, April, 1925, p. 5.

[2] German Patents, under G. 63,543 VI/18 b., February 21, 1925.

[3] The bars cast in sand showed throughout a eutectic to temper-carbon-like structural formation, and had a transverse strength of 48 to 65 kg/mm² with a tensile strength of 28 to 36 kg/mm² (17.8 to 20.3 tons per sq. in.). As these heats had not been deoxidised and consequently did not approach the best values hitherto reached in sand casting by superheating the melt [up to about 75 kg/m:n² transverse strength and 36 to 42 kg/mm² (22.8 to 26.6 tons per sq. in.) tensile strength] they have been omitted from consideration in the treatment of the present Paper.

[4] The specific shock energy of the alloyed samples was two to three times the values hitherto observed in ordinary grey cast iron. For example, heat 5 showed 1.39 mkg/cm²; heat 12, 1.05 mkg/cm².

TABLE I.

1	2	3								4		5			6			7
Heat No.	Type of Heat.	Chemical Composition.								Composition after Heat Treatment.		Transverse Test.			Tensile Test.			Brinell Hardness Number.
		Gr.	C.C.	Si.	Mn.	P.	S.	Ni.	Cr.	Gr.	C.C.	kg/mm².	Deflection in mm.	Fracture.	kg/mm².	Dia. of bars. mm.	Fracture.	
1	A I A I v	0.28	1.98	1.57	0.76	0.068	0.014	—	—	2.34 1.78	0.69 0.60	87.0 90.5	39.5 32.3	* **	44.5† 51.7	5 20	* *	240 249
2	A II A II v	0.14	2.70	1.88	0.62	0.092	0.027	—	—	2.07 2.37	0.73 0.45	85.6 —	38.8 —	*O* —	30.9 ? 36.9 ?	20 20	*** ***	238 167
3	A III A III v	0.21	2.38	1.74	0.60	0.076	0.025	0.89	—	1.98 1.94	0.58 0.73	90.3 75.8	38.8 19.0	*O* **	24.3 ? 26.8 ?	20 20	*** ***	263 255
4	A IV A IV v	0.59	2.48	1.61	0.56	0.083	0.025	2.73	—	— —	— —	— 93.4	— 22.5	— **	31.7 ? 57.2	20 5	*** **	— —
5	A V A V v	0.19	2.88	1.40	0.75	0.052	0.015	2.86	—	2.18 —	0.71 —	90.2 87.4	24.2 23.5	* **	40.7 ? 42.8 ?	20 20	*** ***	2.63 2.73
6	A VI A VI v	0.26	2.60	1.74	0.60	0.084	0.024	3.10	0.80	1.85 —	0.97 —	100.0 102.0	30.2 15.6	* *	69.4 71.4	5 5	* *O*	300 300
7	B I B I v	0.37	1.98	2.58	0.60	0.040	0.020	—	—	1.43 1.43	0.85 0.82	99.25 90.7	43.2 26.0	* *	38.5 28.8	20 20	** **	238 233
8	B II B II v	0.23	2.03	2.49	0.53	0.092	0.03	0.86	—	1.38 1.50	0.78 0.76	— 104.0	— 28.5	— *O*	— 33.5	— 20	— **	— 225
9	B III B III v	0.33	1.99	0.96	0.48	0.060	0.032	3.02	—	1.43 1.77	0.58 0.47	58.3 ? 106.0	109 ? 32.0	** **	— 37.4	— 20	— ***	257 246
10	B IV B IV v	1.54	1.38	2.09	0.55	0.072	0.028	3.17	—	2.72 —	0.20 —	81.8 71.7	8.0 ? 15.6	** *	39.4 33.7	20 20	* **	218 183
11	B V B V v	0.35	2.13	2.06	0.52	0.04	0.026	2.80	0.50	— —	— —	— 102.3	— 27.5	— *	75.7 67.3	5 5	* *	292 285
12	B VI B VI v	0.37	2.05	1.70	0.68	0.06	0.016	2.69	0.47	1.46 —	0.95 —	119.6 128.6	28.7 37.2	*O* *	60.0 56.7	5 5	* *	303 316

O=Perfect fracture. *=Small pipe. **=Large pipe. ***=Very large pipe. † To convert kg/mm² to tons/sq. in. multiply by 0.63.

as free from piping it is surprising that notwithstanding this occurrence of defects such high transverse values were still obtained. No doubt the reason of this is that in the transverse test the neutral fibre plays a relatively small part in straining the material, while the pipe is generally disposed centrally (see Fig. 1, which shows the fracture of certain bars in which the size of the pipe is reduced). On the other hand, the effect of the pipe became all the more unpleasantly observable in the tensile test. For this test, however, the broken pieces from the transverse test were used. They had been turned to a diameter of 20 mm. in order that the tensile test bars might have conical

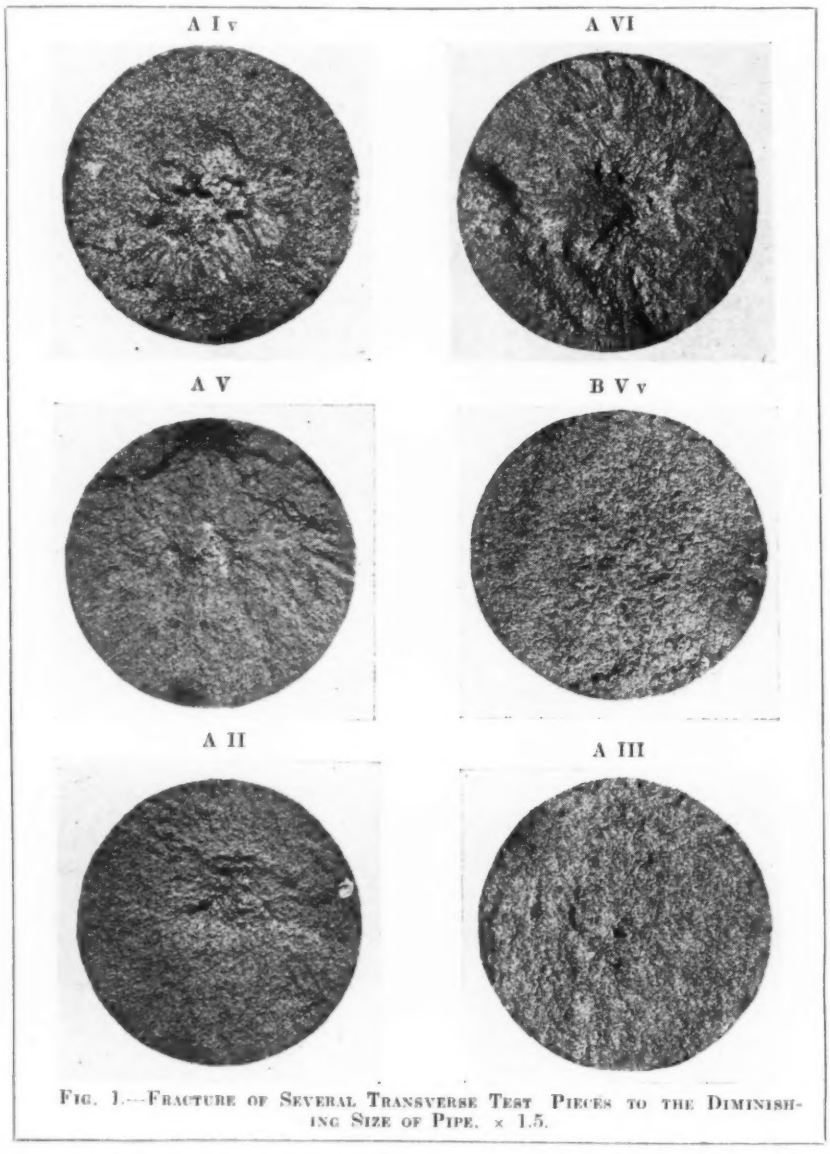


FIG. 1.—FRACTURE OF SEVERAL TRANSVERSE TEST PIECES TO THE DIMINISHING SIZE OF PIPE. × 1.5.

enlargements at their ends. The majority of the tensile bars consequently show much too low values, for notwithstanding the weakening owing to the pipe the maximum load was in relation to the entire cross section. The figures of tensile strength nevertheless show that with tolerably good bars one can count on tensile strengths of over 50 kg/mm.² (31.7 tons per sq. in.). To prove this, small tensile test bars, 5 mm. in diameter (also with conical enlargements at the ends) were made from certain bars in which the pipe formation was less pronounced, the sides which were free from defect being used for the purpose. It will be seen from Table 1 that these bars showed tensile strengths up to about 75 kg./mm.² (47.6 tons per sq. in.), even in cases where these small bars still showed a slight defect in the fracture. Moreover, an elongation of 2 to 4 per cent. was noted in most of these small tensile samples.

(To be continued.)

Iron and Steel Prices.

Scotland Undercut.

In the House of Commons, on June 20, MR. COUPER asked the Parliamentary Secretary to the Overseas Trade Department whether he was aware that pig-iron was at present being sold and delivered at steel works in Lanarkshire and Glasgow district from the Continent at 72s. 6d. per ton, while the price of the same class of pig-iron at the blast furnaces in Scotland was 76s. to 77s. 6d. per ton, exclusive of railway carriage to steel works; that Continental steel plates were being delivered at the shipyards and works on the Clyde at 145s. to 152s. 6d. per ton, as against 162s. 6d. to 167s. 6d. per ton from Scottish steel works; that steel bars were being delivered at 103s. 6d. per ton from the Continent, as against 150s. per ton from the local works; and whether he could give any information as to the conditions as to subsidies, etc., in Continental countries, which resulted in the undercutting of British manufacturers of these commodities.

The SECRETARY TO THE OVERSEAS TRADE DEPARTMENT (Mr. Samuel) gathered from inquiries made that the figures quoted were substantially correct, although they might not relate to identical classes of material. With regard to the last part of the question, he was not aware of any direct subsidies by Governments on the Continent to the industries concerned. For May, 1927, we imported 356,000 tons of iron and steel, and exported 422,000 tons; that was to say, we exported more than we imported, and we exported last month more iron and steel than we had exported since the war, except during May, 1923, during the Ruhr occupation.

Note on the Manufacture of Steam Cylinders for Locomotives and Piston Rings by the Paris-Orleans Railway Company.*

By L. AUDO, Ingénieur des Arts et Métiers, Works Director of the Paris-Orleans Railway Company.

[French Exchange Paper.]

"There will therefore be two things to consider in experimental research: Firstly, the art of obtaining exact facts by rigorous investigation; secondly, the art of applying them by means of experimental reasoning, in order to establish knowledge of the laws of phenomena."

CLAUDE BERNARD.
On "Observation and Experiment."

The manufacture of high-tensile castings presented difficulties at a time which may be regarded as having preceded the war, when the methods of investigation available to foundrymen were rather crude. Manufacture was governed entirely by empiricism and observation. The production of high tensile metals was restricted to a few firms who had acquired a world-wide reputation which was no doubt deserved, and to the special metals employed, which were generally of British origin.

In his Paper presented to the Paris Congress in November, 1925, M. Varlet defined these special irons as follows: metals manufactured with cold blast, at low pressure, in small blast furnaces

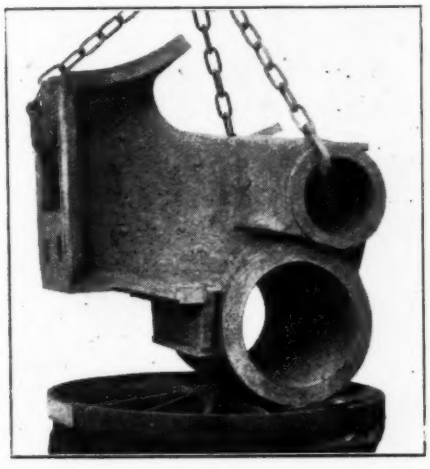


FIG. 1.—AMERICAN TYPE LOCOMOTIVE CYLINDER, WEIGHT 7,260 LBS. TWO CYLINDERS FOR EACH ENGINE MADE FROM ONE PATTERN. ERECTED ON THE VERTICAL PLAN OF SYMMETRY.

heated by coke or wood charcoal. The mechanical properties of such metals, when subjected to similar tests, are undeniably superior to those of irons manufactured in blast furnaces of large capacity worked with hot blast. These differences can be ascribed only to the method of preparation, it being impossible at present to determine their precise cause.

Nevertheless, the productive capacity of small blast furnaces is restricted, whilst the cost price of the iron obtained is high. The difficulties of importation during the war, and later the regrettable influence of the exchange impelled Continental foundrymen to endeavour to obtain high-tensile castings from the products of their own country's soil.

The manufacture of semi-steel projectiles during the war was a first step towards the desired result. But even the manufacture of these was at that time carried out, for the most part, in an empirical manner. The scientific study of such metal by M. Portevin, who has determined its structural characteristics, enabled its manufacture to be carried on methodically and its uses to be extended.

The lack of homogeneity of semi-steel made in the cupola for direct casting, however, does not permit of its employment for castings subjected to friction, in particular for engine cylinders and piston rings. This defect can be remedied by a preliminary pigging. This remelted metal will be made either in the cupola by the founder himself or in the electric furnace by specialists.

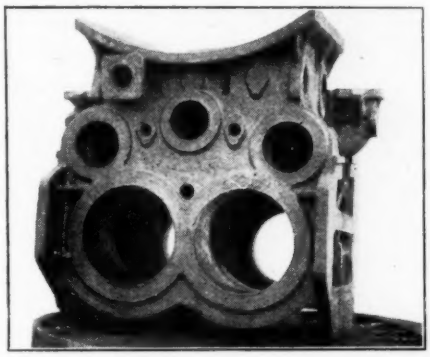


FIG. 2.—LOCOMOTIVE TWIN H.P. CYLINDER OF THE DÉCAPORT TYPE, WEIGHING 11,000 LBS.

Although the cost of the final product is increased by remelting in the cupola, it is possible to obtain high-tensile metals at a practicable price by the employment of new metal, even if of indifferent quality (provided, of course, that it does not contain the injurious elements P and S in large quantities), larger quantities of scrap, and steel scrap— that is to say, cheap products. This steel may be of various origins, manganese steel being excluded as, owing to the presence of that

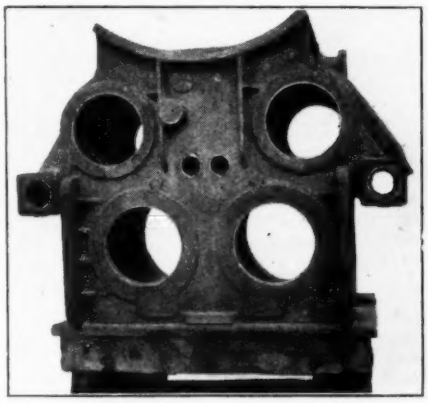


FIG. 3.—LOCOMOTIVE L.P. TWIN-CYLINDER OF THE PACIFIC TYPE, WEIGHT 12,210 LBS.

element, there would be a risk of producing an abnormal quantity of cementite, which would be prejudicial to the strength of the castings and their efficiency in service.

When the author first introduced steel at the works of the Paris-Orleans Railway, he used spring steel derived from the broken leaves of the suspension springs of vehicles. This steel has the following composition:—TC, 0.523; Si, 1.5; Mn, 0.6; P, 0.03; and S, 0.02 per cent. The similarity of this analysis, except as regards the carbon, with that of a good hematite will be noticed.

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* A Paper presented to the Sheffield Convention of the Institute of British Foundrymen.

These leaves are about 15 mm. in thickness and have a maximum length of 20 cm.

He then extended the use of steel to old rivets and clippings from shearing machines—small pieces which are easy to handle and are quickly melted in the cupola.

The preparation of the remelted mixtures should provide, as far as possible, for all the necessary additions of ferro-alloys, so that the re-melting may not necessitate any modification of the charge. In these two operations account should be taken of the influence of the cupola on the various elements, each cupola being, of course, the subject of special study. The use of ferro-alloys with high contents will, of course, be avoided, as they are generally friable and their loss in melting is high. These ferro-alloys, moreover, produce irregular products.

The object of the introduction of steel is, of course, to lower the total carbon content and to adjust it to the silicon content so as to obtain the pearlitic structure. It is evident that the production of high-tensile metals does not necessarily imply the addition of steel, and that by the

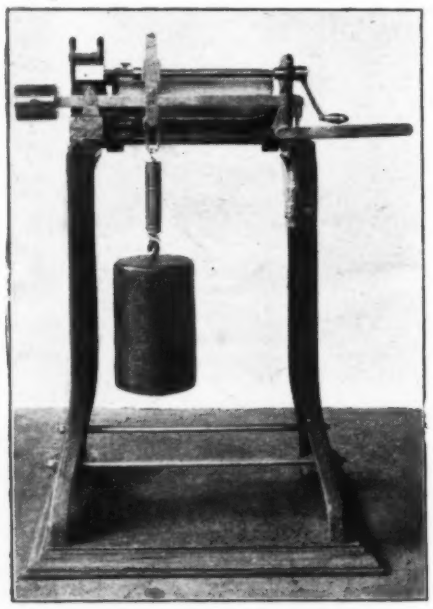

FIG. 4.—SHEARING TEST MACHINE (FRÉMONT TYPE) FOR SMALL BARS OF 5.64 MM. DIAMETER.

use of special irons and of well selected hematite scrap the object in view may be attained more directly.*

Semi-steel has been described as an "artificial metal." But very many articles which one habitually uses nowadays are manufactured artificially, yet one is perfectly satisfied with them. The metal to be obtained, whether manufactured with or without accessories, should have a pearlitic structure. This can be effected by an adjustment of the C and Si contents, which is a very easy operation in the manufacture of steam cylinders and piston rings, castings in which the thicknesses are practically regular and constant. In addition the graphite laminæ should be reduced as far as possible, and the adjustment of the C and Si contents will be effected in such a manner that the final product will be less hard in regard to the rings than the cylinders. As these castings are constantly in frictional contact the wear will take place normally on the ring, a type of casting, the cost of which is relatively low and which can be easily replaced.

In order to obtain this orientation of the Brinell numbers, account must be taken of:—(1) The fact that the thickness of the rings is generally less; (2) the more rapid cooling of these rings.

The mixture for the latter should therefore be modified by slightly increasing the C and Si contents, the basis metals being strictly identical in both cases. On the other hand, while obtaining the pearlitic structure in the rings, a relatively high graphite content may be allowed owing to the lubricating action of this ingredient.

The following is the chemical composition of the metals adopted by the Paris-Orleans Railway Company:—

Steam Cylinders.—TC, 3.0; Si, 1.5; Mn, 0.65; P, 0.2; and S, 0.10 per cent. max.

Piston Rings.—TC, 3.3; Si, 1.7; Mn, 0.65; P, 0.2; and S, 0.10 per cent. max.

The Brinell numbers approximate to 230 in the case of the cylinders and vary from 200 to 210 in that of the rings.

Melting.

The melting of the steel in the cupola sometimes occasions difficulties. In order to overcome them it is desirable to give the melting apparatus somewhat special features, viz:—A height from hearth to throat rather greater than that generally

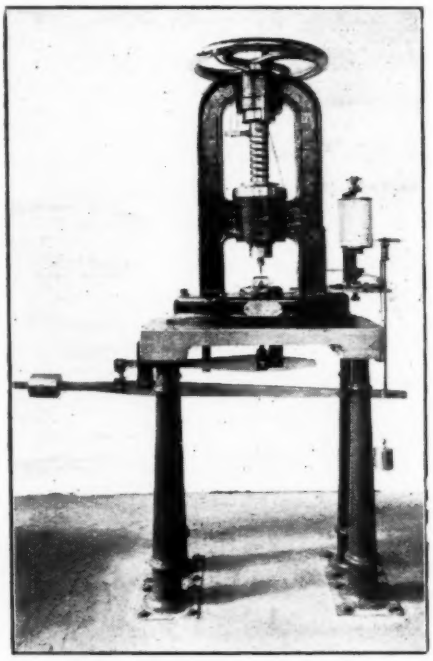

FIG. 5.—TRANSVERSE TESTING MACHINE (FRÉMONT TYPE) FOR SMALL BARS OF 8 × 10 × 35 MM.

adopted; about 6 times the diameter of the hearth may be taken; rectangular tuyeres, wide but not very high in order to prevent oxidation. The total section of tuyeres is one quarter of that of the cupola at their level; The air blown in should be regulated by means of registering apparatus as far as possible. The diagrams should be completed with all the particulars which will enable the foundry manager to exercise his control over the smallest details.

The following should be shown, for example: The time of starting, intentional or accidental stoppages and their causes, the temperature of the metal, the nature of the charge (semi-steel, engineering castings, etc.), the number of slaggings, the precise time of these slaggings, the time of stopping, etc. Thus these diagrams may in fact serve as a daily record of the work of the foundry.

The charges are made in the following order: the steel, the pig, the scrap. The furnace is lightly forced with 12 to 14 per cent. coke, the best quality being chosen. All these conditions being observed, the pressure of the air blown in will be about 35 to 40 cm. (14 to 16 ins.).

In addition to the features already mentioned, the cupolas used by the Paris-Orleans Railway Company are furnished with receivers with a capacity of 2½ tons. These enable the metal to be protected from the recarburising action of the coke, which is appreciable in an ordinary cupola. Thus in this apparatus the recarburisation is only 0.05 per cent. with carbon contents of 3.0 per

* See "Study on Pearlitic Metal," by M. Le Thomas, Marine Engineer, "Fonderie Moderne," February, 1926.

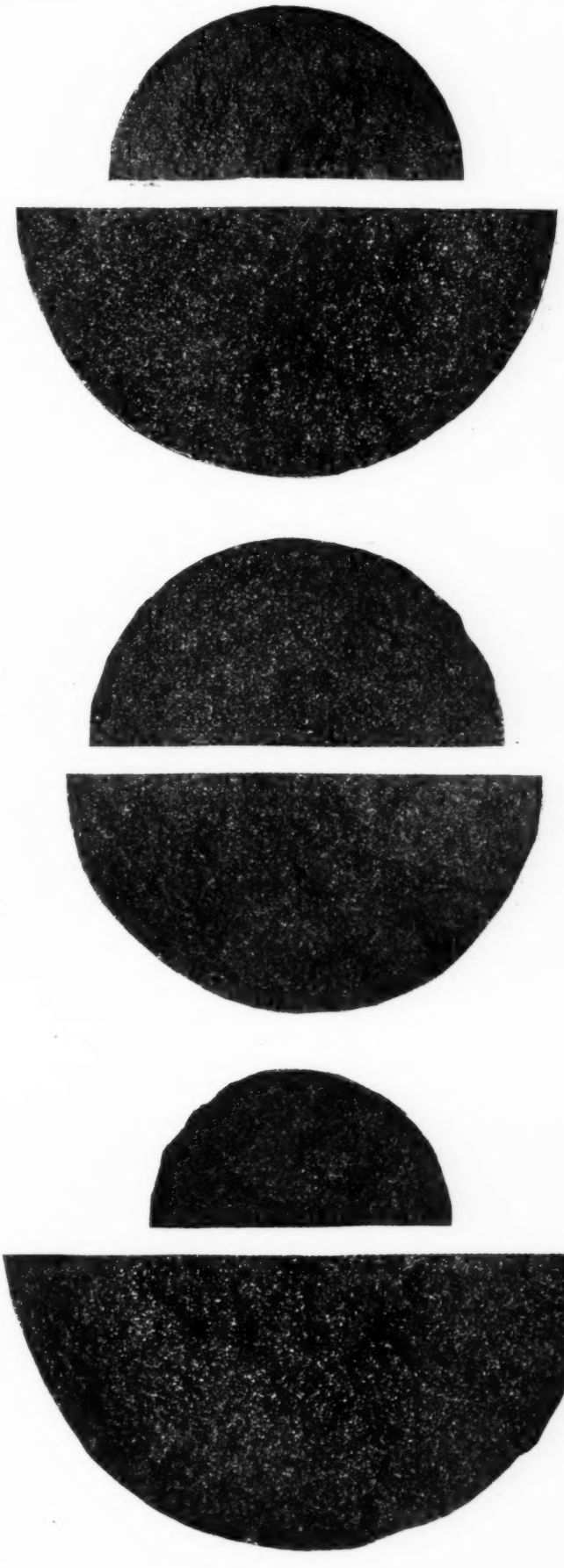

Fig. 6.—Fractures from Piston Ring Iron, All Cast from the Same Iron. Actual Size.

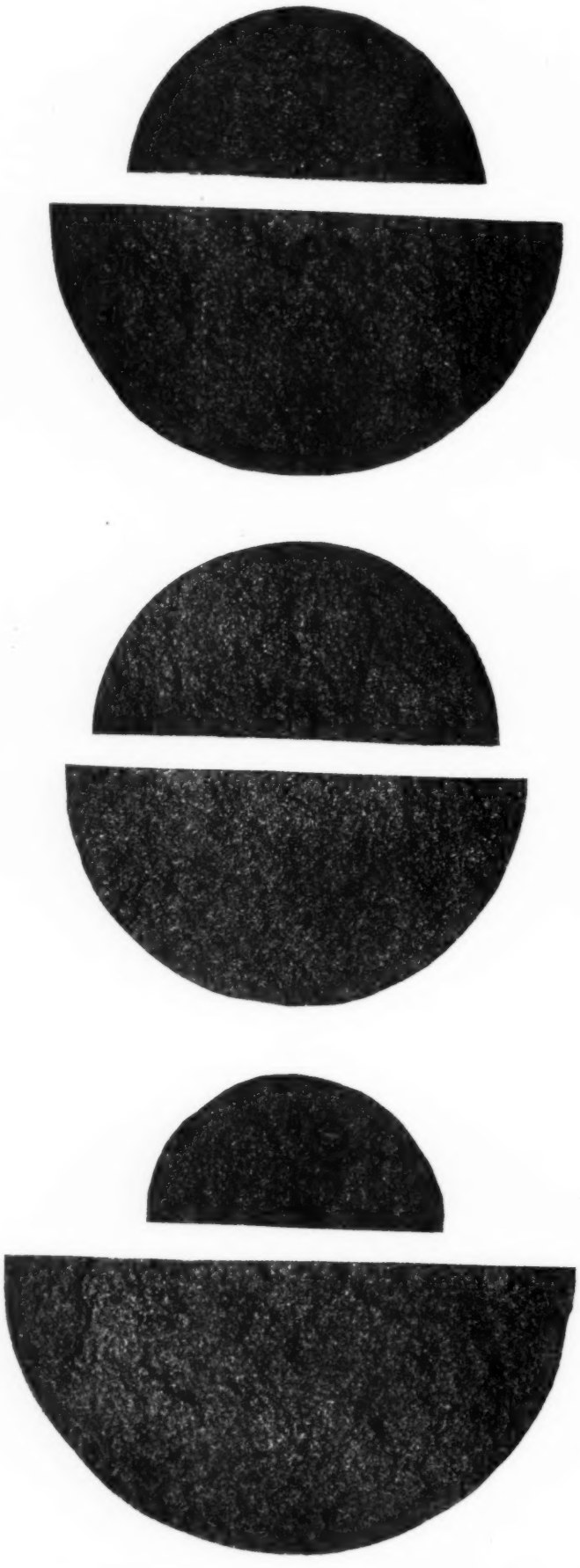

FIG. 7.—FRACTURES OF RUNNERS TAKEN FROM A STEAM CYLINDER IRON. ALL HAVE BEEN CAST FROM THE SAME IRON. ACTUAL SIZE.

cent. The receivers are furnished with an inspection hole enabling the quantity of metal contained in them to be ascertained. Their capacity of 2½ tons enables small and medium cylinders to be drawn in a single tapping, and large cylinders up to 5½ tons in two tappings. Under favourable conditions they have given 6½ tons without botting in.

The proportion of steel to be used must obviously vary according to the basis metals employed and the thickness of the castings to be obtained. The quantities of steel are determined by the chemical analyses of these basis metals and of the final product required, and also by micrographical examination, which should show the pearlitic structure.

Inspection Conditions.

The French railway companies repair and maintain their plant in their own works. Orders for new material are generally entrusted to private enterprise. Their manufactures, particularly those of steam cylinders and piston rings, therefore cover a large number of types, but on the other hand only a small number of castings to each type. The terms of inspection for these castings apply to work executed by private manufacturers as well as to that done by the works of the companies themselves. At present the inspection tests are as follows:

Steam Cylinders.

Shock test: hammer 12kg. (26 lb.); test pieces of 40 by 40 by 200 mm. (1.5 by 1.5 by 7.8 ins.); distance between knife supports 160 mm. (6.3 ins.); first blow 30 cm. (11.8 ins.); successive increases 5 cm. (1.9 ins.); minimum rupture 50 cm. (19 ins.).

Tensile test: minimum rupture 18 kg. per sq. mm. (11.4 tons per sq. in.) on bars suitable for the available machines.

Porosity: hydraulic test at a pressure equal to that of the working pressure of the boiler increased by 1 kg. in the case of high pressure cylinders; at a uniform pressure of 10 kg. (22 lbs.) in the case of low pressure cylinders.

Piston Rings.

Shock test: identical with that used for the cylinders. *Tensile test*: identical with that used for the cylinders. *Transverse test*: a ring machined on its four faces to 26 by 15 mm. (1.0 by 0.59 ins.) is opened by two saw-cuts giving an opening of 25 mm. (0.98 ins.). The segment thus obtained is suspended to a fixed point, the centre of the opening coinciding with the horizontal diameter. Tension is exerted vertically by the successive addition of weights arranged on a plate until rupture takes place.

The characteristics required are given in the following table:—

External diameter of the finished rings.	Breaking load.		Opening at breaking point.	
	Minimum.	Average.	Minimum.	Average.
348	135	140	75	100
368	128	133	85	113
388	120	128	95	125
408	110	115	100	130
428	105	110	105	135
448	100	105	115	145
468	95	100	120	150
488	90	95	130	160
508	87	92	140	170
528	85	90	150	180
548	82	86	165	195
568	78	82	180	210

From the point of view of characterising the metals for cylinders and piston rings, the tests such as have been described cannot indicate very clearly the actual mechanical properties of the products cast. Here the shock test has no significance, while the tensile test, as M. Portevin has pointed out, is frequently impaired by errors.

A few months ago the author had recourse to the tests recommended by the Association Technique Française de Fonderie, viz., transverse and shearing tests on small bars. To these were added the hardness test, which is indispensable in determining the properties of castings subject to friction.

The test bars are taken as test pieces poured with the castings, their dimensions being identical with those of the castings, so that the bars and castings may both have the same "thermal history."

The transverse test carried out on the Frémont machine, which registers the curves, is most valuable in examining metals designed for piston rings, owing to the possibility of studying these curves and the ease with which the test can be repeated.

The tests made by the Paris-Orleans Railway Company applied to a large number of cases, so as to find simple formulæ connecting the old tests and the new. This was for the purpose of

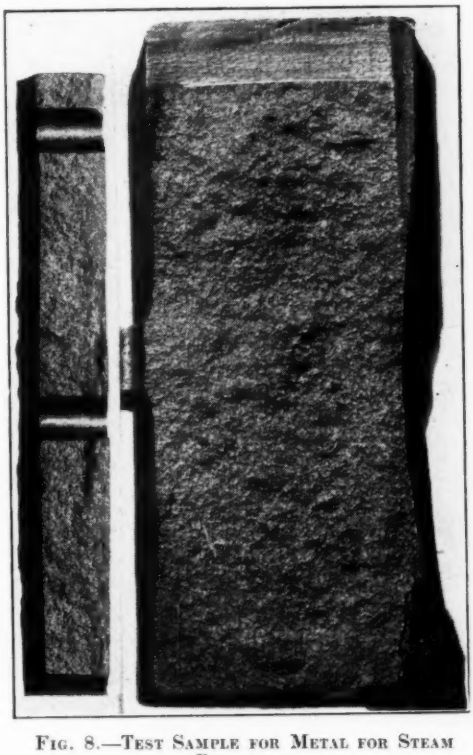

FIG. 8.—TEST SAMPLE FOR METAL FOR STEAM CYLINDERS.

Note the similarity of grain in the two different sections, the smaller of which (25 mm.) was attached at right angles to the larger (55 mm.). Two-thirds natural size.

at once imparting the results obtained to private foundrymen without their requiring to carry out themselves the lengthy research work involved.

The formulæ established by the railway company are obviously of particular interest in connection with its own manufactures. It must be remembered that the relations in question are influenced by the chemical composition of the metals employed, the rate of cooling, etc. These formulæ are as follows:—

Tensile strength = 0.916 shearing strength — 1.2.
Shearing strength = ($\triangle \times 0.23$) — 25.

Manufacture.

A. *Steam Cylinders.*—Contrary to the method generally adopted in Great Britain, where cylinders are cast on the flat, in France and Belgium they are cast vertically. With regard to the moulding mention will only be by way of reminder of the different processes employed:

(1.) By an ordinary pattern having loose side pieces;

(2.) With a pattern and core boxes for the sides, the copes being filled round the cores after being put in place (a process very suitable in repetition practice);

(3.) Using an ordinary pattern and a series of box parts.

The last process is that in general use by the French railway companies which do not manufacture in quantity.

The most suitable method of pouring should be bottom casting and at an inverse pressure. Single cylinders should be cast at the base of

the cylindrical body, and double cylinders at the bosses for fixing them to the engine frame, which will ensure a maximum passage for the first metal introduced. The inverse pressure, which will amount to 15 per cent., is obtained by narrowing the upper part of the gate. A quiet pouring will thus be secured. The metal is received in a decantation basin of the Wan Riet type, either provided with a stopper or not.

The rate of pouring must be dependent upon, (a) the weight of the cylinder; (b) the average value of its horizontal section in relation to the

Fig. 9a.—Piston Ring Iron (1) Cementite, (2) Light Reflections from the Graphite × 700.

weight, so as to obtain an ascensional linear speed sufficiently low to enable the gases to escape from the cores; and (c) the number of the cores, *i.e.*, the difficulty of the liquid metal in entering the mould.

Taking these considerations into account, the author has adopted the following speeds for filling:—

					Pouring Time.
44 lbs.	per second for	1	ton cylinders	..	50 seconds.
66	,, ,,	2	,, ,,	..	70 ,,
81	,, ,,	3	,, ,,	..	80 ,,
99	,, ,,	4	,, ,,	..	90 ,,
110	,, ,,	5	,, ,,	..	100 ,,

The cylindrical casing and the distributors (valves) are surmounted by surplus metal from 4 to 6 ins. in height, its thickness being equal to that of the cylinder. These projections are not, properly speaking, feeding dead heads. Their upper parts are connected towards the outside so as to form a "spout" enabling the mould to be lightly "washed" in case of accidental boiling. It will be found that vertical casting facilitates the elimination of possible blow-holes.

Piston Rings.

The tangential casting of cylindrical work, whether by bottom casting alone or by bottom casting with a return gate, has long been recommended in connection with piston rings. Its purpose, according to those who advocate it, is to produce in the mould a rotary movement of the metal which helps to loosen the slag along the walls. If this movement could be effected over the entire height of the casting and during the

Fig. 9b.—Steam Cylinder × 450.

entire duration of pouring, bottom casting would undoubtedly fulfil its purpose and would be desirable.

Unfortunately, this is not the case. The rotary movement is produced effectively at the begin-

Fig. 9c.—Steam Cylinder Iron × 450.

ning of the filling, but it takes place only in the drag, and becomes progressively feebler towards the surface of the liquid, ceasing at a height of 10 to 15 cm. As the hottest metal is at the middle circumference it breaks the upper film of cooler

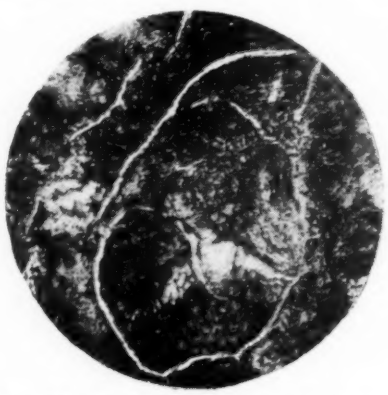

Fig. 9d.—Steam Cylinder Iron × 450.

metal, and brings any slag that may have formed down on to the walls.

With top pouring by filtration the author has obtained excellent results, and has adopted it generally for cylinder work.

The piston rings are poured open by means of a basin placed astride the cope and the core.

The lower part of the basin is pierced with 15 mm. (0.59 in.) holes, their number varying with the weight of the casting to be poured. The filling is done at a speed of 220 lbs. in 15 seconds, that is to say, quickly.

This rate of pouring is the result of two facts which are readily observable in connection with the filling of open moulds:—(1) The presence in the liquid metal of an ascending movement proceeding from the walls of the mould to the central stream, which movement carries the impurities towards it. This is the same phenomenon which all have observed on the surface of a ladleful of hot metal; (2) the production, owing to the rapid fall, of a disturbance favouring the freeing of these impurities.

Certain authors have recommended learned formulæ for the purpose of determining the rate at which moulds should be filled. The author, however, does not consider it possible to apply such formulæ, owing to the differences in thickness and the varying amount of coring in cast-

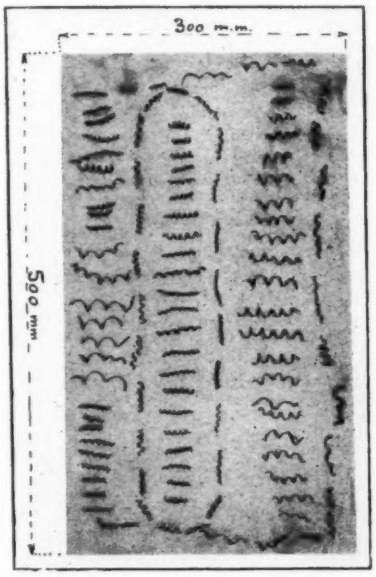

FIG. 10.—TURNINGS FROM A C. I. CYLINDER.
Note the number of spirals (8 and 9) and the length of the turnings (up to 2¾ ins.). They are indicative of the good machining and mechanical quality of the iron from which they have been formed.

ings. Each casting must be the subject of special study. Some must be poured quickly, others less quickly, and others, again, slowly. Then, in certain cases, the method of slow pouring so frequently recommended by M. Ronceray will be adopted, this method being one which gives remarkable results, owing to the possibility of obtaining by it sound castings without feeding heads.

Machining Rings and Boring Cylinders.

The piston rings of engines and valves are machined under the following conditions:—(1) Roughing down to the diameters D and D1 determined by the formulæ:

$$D = d + \frac{d \times 0.07}{3.1416} + 4 \text{ mm.}$$

$$D1 = d1 + \frac{d \times 0.07}{3.1416} - 4 \text{ mm.}$$

in which d is the diameter of the cylinder and d1 the diameter of the cylinder less twice the thickness of the ring.

(2) Cutting the rings in two planes passing through the axis of the cylinder, their distance at the periphery being

$$e = D \times 0.07$$

(3) Pressing the ring by means of two or three collars made of flat iron with a maximum thickness of 3 mm. (0.12 in.) and 35 to 40 mm. (1.3 to 1.5 ins.) wide.

(4) Truing and finishing to the diameters:

External diameter d = diameter of the steam cylinder at its smallest part;

Internal diameter d1 = d less twice the thickness of the ring.

The rings are adjusted in the cylinder so that the play between the section planes is equal to $\frac{3}{1000}$ of the diameter at the smallest part. The purpose of this play is to enable the ring to expand freely.

The rings are replaced: (1) When they are broken or seized, (2) when the distance between the two edges of the section reaches $\frac{1}{100}$ of the diameter, (3) when the lateral play in the grooves reaches $\frac{3}{10}$ mm., (4) when their elasticity is insufficient, i.e., when the distance between the sections when free is only $\frac{3.5}{100}$ of the diameter.

Periodical inspections are made as follows:—
In a summary manner, for every 10,000 km. run.
In detail: After every 40,000 km. for the locomotives of express or fast trains.

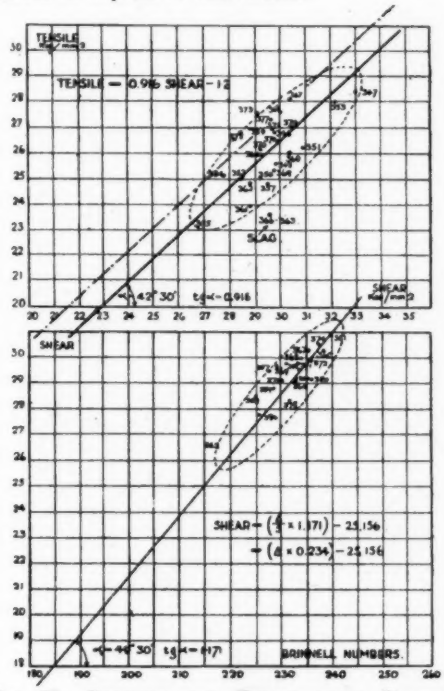

FIG. 11.—SHOWING THE RELATIONSHIP BETWEEN THE SHEAR TEST AND THE TENSILE, AND THE SHEAR TEST AND THE BRINELL NUMBERS.

After every 35,000 km. for the locomotives of ordinary and mixed trains.

After every 30,000 km. for the locomotives of goods trains.

After each stoppage the amount of wear in the cylinders and jackets is measured with a micrometric gauge. In particular the greatest vertical diameter and the smallest horizontal diameter are generally measured. The wear is greatest in the middle of the stroke in the case of pistons with rods, and at the ends of the stroke and opposite the inlets in that of pistons without them. The cylinders are rebored when the difference between these two diameters is 1 mm. or more, when traces of seizing are found, or if scratches 1 mm. or more in depth have been caused.

The cylinders are reformed when their thickness reaches a figure given by the formula:—

$$E = \frac{P\,(D + 30)}{500}$$

in which D is the original diameter of the cylinder in millimetres and P the working pressure of the boiler in kg. per sq. cm. For low pressure cylinders P is made to equal 10. E should in any circumstances be more than 10 mm.

Supervision of Manufactures.

All the observations made during casting, the mechanical strength of the metals and the analytical and micrographical data are registered by

the foundry. The steam cylinders are given an order number, and the piston rings a casting number as they come from the foundry, these numbers being in relief on the castings.

The machine shops of the Company's system or the sections using the castings carefully note any observations made during the machining, erecting and dismantling. These particulars are communicated to the foundry which, after comparing them with the observations already made by them, may be able to introduce useful modifications into the next work of a similar nature produced.

The most conclusive results are those obtained during the periodical inspections of the cylinders and piston rings. Thus rings will obviously be regarded as good which have done long journeys (longer than the minima previously mentioned), which show only slight wear on being taken to pieces, and which have affected the wear of the cylinders only slightly.

The data of a physical nature and the deductions drawn from them with regard to the satisfactory working of the products enable a considerable saving to be made in fuel and lubricants. They also enable a factor which is by no means negligible to be determined—the skill of the engine driver.

Results.

The average distance run by 100 superheated engines on fast trains was 3,410 miles. The wear of the engine rings are round about 3 mm. (0.12) and the corresponding wear in the cylinders is $\frac{1}{150}$ mm.

These are a few particulars based upon recent observations. The author considers these results satisfactory, and he would be glad if these notes should prove useful to his colleagues in the foundry industry. Should their own results be better he would beg them to communicate them, together with their methods, for the greater advantage of all.

Passenger Train Engine No. 3650 (*superheated*).

Diameter of wheels .. .. 1.9 m. (74 ins.)
Circumference of wheels .. 5.97 m. (19 ft.)
Stroke of engine pistons .. 0.65 m. (25 ins.)
Working pressure of boiler .. 16 kg. (35.2 lbs.)

Cylinders.	Diameter. Before.	Cylinders. After.	Distance travelled.	Wear in rings on dismantling. in min.
	Mm.	Mm.	Miles.	
HP Right ..	423.53	423.57	34,659	3
HP Left ..	423.65	423.68	,,	4
LP Right ..	640.30	640.35	,,	2
LP Left ..	640.55	640.55	,,	2
EG Right ..	270.20	270.20	,,	1
EG Left ..	270.20	270.20	,,	1

N.B.—The total rectilinear distance travelled by the rings in the cylinders was 8,543 miles.

Passenger Train Engine No. 3557 (*superheated*).

Same characteristics as the foregoing.

Cylinders.	Diameter. Before.	Cylinders. After.	Distance travelled.	Wear in rings on dismantling. in min.
	Mm.	Mm.	Miles.	
HP Right ..	422.60	422.63	33,975	3
HP Left ..	423.90	424.10	,,	3.5
LP Right ..	643.80	643.85	,,	3
LP Left ..	643.95	644.00	,,	3
EG Right ..	270.15	270.15	,,	1
EG Left ..	270.15	270.15	,,	1

N.B.—Total rectilinear distance travelled by the rings in the cylinders: 7,397 miles.

Goods Engine No. 5822 (*superheated*).

Diameter of wheels .. .. 63 ins.
Circumference of wheels .. .. .. 16 ft. 6 ins.
Stroke of pistons .. .. 24.4 ins.

Cylinders.	Diameter. Before.	Cylinders. After.	Distance travelled.	Wear in rings on dismantling. in min.
	Mm.	Mm.	Miles.	
Right	622.97	623.00	35,017	3
Left	623.95	623.99	,,	3

Rectilinear distance travelled by rings in cylinders: 8,648 miles.

Goods Engine No. 5850 (*superheated*).

Cylinders.	Diameter. Before.	Cylinders. After.	Distance travelled.	Wear in rings on dismantling. in min.
	Mm.	Mm.	Miles.	
Right	624.00	624.08	44,818	5
Left	625.00	625.07	,,	4

Rectilinear distance travelled by rings in cylinders: 13,522 miles.

Goods Engine No. 5878 (*superheated*).

Cylinders.	Diameter. Before.	Cylinders. After.	Distance travelled.	Wear in rings on dismantling. in min.
	Mm.	Mm.	Miles.	
Right	622.92	623.00	62,758	4.5
Left	622.95	623.01	,,	4.5

Rectilinear distance travelled by rings in cylinders: 13,980 miles.

A Neck Ring.

BY H. LITTLEHALES.

The accompanying picture exhibits the metal craftsman's art in its saddest form, for it is a photograph of the neck ring of a slave or prisoner. This ring was found at a considerable depth beneath the ancient High Street of Winchester when quite recently the road was taken up for the laying of the main drain. As will be seen by the illustration, the neck ring has one or two links attached to it and is itself of such a character that it appears to have been welded on to the neck of the slave or prisoner.

AN ENGLISH PRISONER'S OR SLAVE'S NECK RING.

It is not possible to detect the joint where we may suppose the two ends of the ring to have been welded together on the slave's neck for the ring is much rusted. From the two following facts, however, it is conceivable that the poor body was buried with the ring still round the neck:—(1) That the ring is closed, not open, and (2) that a skeleton was found near the spot where the ring was discovered.

The ring is now in one of the museums of the City of Winchester, and we are indebted to the courtesy of the custodians for our photograph.

The Properties of Coke Affecting the Cupola Melting of Steel.*

By JAMES T. MacKENZIE, Chief Chemist, American Cast Iron Pipe Company, Birmingham, Ala.

[American Exchange Paper.]

Steel scrap in cupola mixtures has challenged the attention of foundrymen everywhere for a number of years. Many papers have been presented in the technical Press and before the various technical societies dealing with the strength of irons obtained from such mixtures, and it is almost universally accepted that steel scrap does increase the strength of the iron quite out of proportion to its effect on the chemical analysis. The recent work of Piwowarski on the influence of graphite nuclei has provided a valuable theory as a basis for future investigation and may serve to assist in the interpretation of some heretofore anomalous results. Accurate thermal data may be expected in the foundry literature of the future, because the development of the optical pyrometer has placed within the reach of everyone the means of observing and recording temperature. Recent investigation has shown that the disappearing filament type of pyrometer is accurate, within very small limits, for all types of foundry irons and the quickness with which readings may be made, even by an inexperienced observer, is remarkable. Many of the conflicting results obtained by the use of steel scrap are due undoubtedly to differences in melting conditions, of which the temperature is probably the most important. "Hot iron" is an indefinite term and may mean one thing when spoken by the stove-plate founder and something entirely different when spoken by the manufacturer of heavy castings.

Another cause of misunderstanding in discussions of steel has been the confusion of test bar and casting. The iron that will make the strongest test bar of say 1.25 in. dia. and 15 in. length will certainly make a poor radiator, if it will make it at all, and will be almost as unsuitable for a very heavy casting. This is one of the reasons why various statements exist as to the maximum permissible percentage of steel scrap in the charge, which, if memory fails not, varies from zero to 100 per cent.

Inextricably associated with the temperature of melting and the chemical composition of the melt, is the problem of oxidation. With steel in the mixture, the lower the melting temperature, the greater the oxidation, the lower will be the carbon, silicon, and manganese, and the higher will be the freezing point and the gas content. Consequently the practical fluidity, or "coulabilité" as Guillet and Portevin call it, is rapidly reduced.

This paper is concerned chiefly with the total carbon absorbed by steel scrap when melted with the various cokes of an unusual collection, not complete, but well representative and containing the extremes likely to be encountered. The cupola used was a Number 0 Whiting with a 27-in. shell, lined to 18 in. with clay brick, with 2 tuyeres 17 in. above the mantel plate and 70 in. below the charging door. The lining was straight from mantel to charging door. The tuyeres measured 9 in. by 3 in. at the lining; and the blast, supplied by a fan, was fairly constant at 4 oz. per sq. in. In some of the early heats the volume increased as the stock fell in the stack, but the practice was changed as soon as this was noted and thereafter the stack was kept full of coke throughout the melting period. None of the heats reported here was affected by this to a great extent, though in several heats a slight drop in carbon on the last tap or so may be noted. The cupola was lighted in the usual way and the wood allowed to burn away by natural draft, coke being put on to have the bed at 30 in. above the tuyeres when this was accomplished. The wind was then put on for five minutes to heat the tap hole and basin, after which the bed was built to 40 in. with fresh coke, the breast stopped in, the charges quickly put in and the blast put on as soon as the stack was filled (about 5 min.). The first tap was made in 25 min., when usually 25 to 75 lb. of iron were obtained, after which melting proceeded at the rate of approximately 1,000 lb. per hr. A shank ladle of 200 lb. capacity was used for handling the molten iron which was poured into pigs on the first two or three taps and then into well blacked and dried test moulds, giving the 2 × 1 × 28-in. bars cast vertically. Charges were 100 lb. with sufficient 50 per cent. ferro-silicon and 80 per cent. ferro-manganese to give the indicated composition. These were placed on top of the steel in the centre of the cupola. The coke charge was kept constant at 25 lb., except in the case of the high volatile petroleum cokes, Parco, Wichita Falls, and Shell. No fluxing was attempted, but there was usually a thin liquid slag which was allowed to run into the ladle and was skimmed off before pouring. The amount of this slag varied practically with the ash content of the coke, for it seems that the higher the ash the greater the oxidation of the steel and the proportion of ferrous oxide to silicon dioxide is thus automatically maintained. There was very little cutting of the lining except in the melts with the very high-ash cokes.

TABLE I.

Coke.	Oven.	Ash.	Volatile.	S.	Porosity.	Shatter.	S. G.	C.	Appearance of coke.
Dayton ..	Bee Hive ..	17.0	0.4	1.7	59	70	1.94	1.73	Dull grey, overburned.
Sewanee ..	Bee Hive ..	16.9	0.7	0.6	—	80	—	1.80	Silver bright.
Fire Creek ..	Bee Hive ..	5.8	0.6	0.5	59	93	1.94	2.10	Dull, light grey.
Bradford ..	Bee Hive ..	3.9	0.5	0.5	50	50	1.80	2.81	Silver bright.
A.B.C. ..	By product	10.0	0.7	0.6	46	68	1.92	2.50	Dull, dark grey.
A.B.C. ..	Unbroken	—	—	—	—	—	—	2.17	Dull, dark grey.
Barrett ..	Bee Hive ..	1.1*	0.9	0.4	47	88	1.85	3.38	Dull black.
Bayonne ..	Unknown ..	0.1	5.0	1.2	—	75	—	3.54	Dull black.
Parco	Still residue	0.2	15.0	0.5	—	55	—	4.27	Shiny black.
Wichita Falls	Still residue	0.3	14.0	1.4	51	52	1.92	No melt	Dull black.
Shell	Still residue	1.4	18.0	1.4	—	—	—	No melt	Dull black, badly broken.

* Largely dust from long storage—the new coke runs about 0.4 per cent. ash. This extraneous excess would not affect the properties of the coke.

Carbons calculated to basis of 2.00 per cent. Si, 0.10 per cent. P, and 0.50 per cent. Mn.

Shatter is amount remaining on 2 in. screen after 4 drops from 6 feet.

Porosity (or cell space) determined according to A. S. T. M. standard method.

Table I shows the results for total carbon which are calculated from the detailed data of Table II. The base was taken as 2.00 silicon; 0.10 phosphorus; and 0.50 per cent. manganese. Pure iron holds 4.3 per cent. carbon in solution; 80 per cent. manganese, about 6.7 per cent. carbon; and 21 per cent. silicon (Fe_2Si), or 15.6 per cent.

* A Paper presented to the Sheffield Convention of the Institute of British Foundrymen on behalf of the American Foundrymen's Association.

phosphorus (Fe_3P), throw the carbon to zero. Therefore the corrections are as follows:—

For each per cent. variation in manganese (3.4/80), 0.04 per cent. C.

For each per cent. variation in silicon (4.3/21), 0.21 per cent. C.

For each per cent. variation in phosphorus (4.3/15.6), 0.28 per cent. C.

The calculations are admittedly doubtful, but the sum of all three corrections are less than 0.20 per cent. in nearly all cases, and it seems the only hope of reducing all the melts to a common basis. Table II is given to enable anyone to make a detailed study of the actual results obtained undisturbed by the assumption of the author.

Turning again to Table I, it seems that in the beehive cokes the carbon rises as the ash falls, but in no regular way; while in the pure cokes the same thing is noted in regard to volatile matter. It is at once apparent that the structure of the coke is of fundamental importance and may counteract to a considerable extent the effect of the composition. The two high-ash cokes have little difference in structure and little in carbon absorption. The Bradford is much softer than the Fire Creek (which is extraordinarily hard and dense), and so carburises to an extent not warranted by the difference in ash. Coming to the pure cokes, the Barrett is hard and dense (really a true coke), the Bayonne quite cellular, and the others highly cellular. In fact, the Wichita Falls burned along the cell walls so rapidly that small pieces were blown out of the stack in a veritable shower, which no doubt accounted for its failure to melt. The Parco was much better, and gave few sparks of this nature, but required an inordinately long time to begin melting, and then melted very slowly. The furnace was 70 minutes in blast before any iron melted, and then it came slowly but hot, throwing out great quantities of "kish" as it was being poured. The Shell coke was so broken up in its long journey in bags from the Pacific Coast that it was almost useless to try it, but under the heat it practically melted down to a soft, gummy mass, so no deductions could be made from its original structure. While it is not thought that the volatile matter has any influence *per se*, on escaping it probably leaves the coke in a more porous condition than originally.

TABLE II.

Coke.	Date.	Bar.	Actual analysis. C.	Si.	P.	Mn.	S.	$CaCO_3$	Breaking load.	Defl.
Dayton	3/27/24	124	1.72	2.02	0.09	0.94	0.228	1.70	4,780	0.36
		125	1.70	1.76	0.07	1.08	0.184	1.63	5,000	0.35
	4/30/25	219	2.04	1.13	0.16	0.36	0.192	1.86	4,300	0.28
		220	1.96	0.88	0.11	0.38	0.173	1.73	3,250	0.21
	5/4/25*	225	1.89	3.39	0.13	0.67	0.236	2.18	3,600	0.29
	(4/30/25)	226	1.99	3.42	0.13	0.42	0.254	2.29	4,230	0.34
Sewanee	5/5/25	227	1.96	1.88	0.13	1.04	0.105	1.91	5,100	0.34
		228	1.73	1.71	0.12	0.30	0.102	1.68	5,100	0.34
	5/8/25*	233	2.62	1.95	0.14	0.73	0.156	2.60	3,700	0.32
	(5/5/25)	234	2.56	1.86	0.14	0.37	0.155	2.53	3,000	0.22
Fire Creek ..	8/14/25	316	2.09	2.22	0.10	0.33	0.102	2.13	3,700	0.31
		317	2.18	1.45	0.10	0.45	0.098	2.06	4,600	0.28
Bradford	7/30/25	300	2.78	2.55	0.09	0.38	0.119	2.90	3,650	0.35
		301	2.75	1.89	0.05	0.29	0.107	2.73	3,680	0.33
	8/1/25*	304	3.45	1.71	0.12	0.33	0.140	3.39	3,180	0.40
	(7/30/25)	305	3.25	2.04	0.11	0.34	0.134	3.26	3,000	0.35
A.B.C.	3/19/24	113	2.48	2.94	0.05	1.52	0.111	2.64	3,090	0.28
		114	2.74	2.05	0.05	1.24	0.121	2.72	4,570	0.41
	5/1/25	221	2.34	1.64	0.11	0.40	0.126	2.26	3,800	0.26
		222	2.23	1.40	0.10	0.27	0.113	2.11	3,250	0.21
	5/6/25*	229	2.85	2.46	0.12	0.51	0.173	2.95	3,500	0.34
	(5/1/25)	230	2.85	2.30	0.14	0.67	0.156	2.90	3,600	0.37
	7/17/25	288	1.45	0.04	6.46	0.26	0.161	2.80	1,050	0.09
	(20% Fe_3P)	289	1.81	0.04	4.80	0.24	0.124	2.70	920	0.07
	7/20/25	292	1.91	4.35	0.08	0.50	0.140	2.35	3,500	0.32
	(20% Fe_2Si)	293	2.15	3.60	0.15	0.48	0.132	2.49	3,300	0.30
		294	1.98	3.51	0.15	0.49	0.131	2.30	3,200	0.27
A.B.C. Bed ..	7/21/25	295	2.58	2.22	0.11	0.29	0.160	2.63	3,450	0.37
With 40% ..	(10% Fe_2Si)	296	2.65	1.75	0.16	0.28	0.149	2.61	3,400	0.37
Barrett Above ..	8/5/25	308	2.50	2.83	0.06	0.27	0.188	2.68	3,450	0.29
(Steel from Shell Coke Experiment)		309	2.72	0.69	0.08	0.20	0.154	2.44	3,000	0.21
A.B.C. 50 per cent.	8/29/25	336	3.09	1.95	0.08	0.38	0.189	3.10	3,400	0.34
W. Falls, 50 ,,		337	3.21	0.80	0.12	0.26	0.192	2.97	3,060	0.22
AB.C.	1/21/27	402	2.17	1.04	0.09	0.39	0.062†	1.97	3,690	0.27
Unbroken (Steel .. Round)	3/1/4	403	2.12	1.52	0.11	0.47	0.077	2.02	4,290	0.27
		404	2.16	1.95	0.08	0.47	0.066	2.15	4,970	0.44
		405	2.26	1.00	0.12	0.25	0.070	2.16	3,360	0.25
	1/22/27	406	2.30	1.52	0.07	1.29	0.110	2.20	4,700	0.31
		407	2.30	1.50	0.06	0.29	0.122	2.20	4,200	0.29
(Steel, ¾ in. Round)		408	2.27	1.85	0.09	0.36	0.104	2.24	4,240	0.28
		409	2.52	0.95	0.05	0.41	0.102	2.30	4,100	0.28
		410	2.31	2.32	0.08	0.28	0.080	2.38	3,740	0.29
	1/29/27	411	2.00	2.26	0.07	0.32	0.115	2.05	3,730	0.27
(Steel, ¼ in. to ½ in. thick)		412	2.14	2.14	0.08	0.28	0.118†	2.17	3,510	0.24
Barrett	3/13/24	107	3.37	2.25	0.02	0.61	0.092	3.42	3,200	0.46
		108	3.27	3.28	0.04	1.32	0.080	3.52	1,950	0.42
	3/31/24	129	3.47	1.20	0.18	0.52	0.266	3.30	3.120	0.39
		130	3.28	1.70	0.17	0.48	0.130	3.22	3,320	0.43
	4/2/24	131	3.11	1.96	0.89	0.40	0.119	3.32	3,660	0.34
	5/2/25	223	4.05	1.50	0.09	0.44	0.106	3.95	2,100	0.49
(Coke, 35 lbs.)		224	3.92	1.17	0.11	0.29	0.104	3.75	2,600	0.41
	5/7/25*	231	4.18	2.36	0.12	0.54	0.097	4.26	1,930	0.57
	(5/2/25)	332	4.09	2.70	0.12	0.38	0.095	4.23	1,750	0.51
Bayonne	6/11/25	240	3.75	1.36	0.05	0.61	0.122	3.62	2,600	0.36
		241	3.68	0.90	0.06	0.55	0.170	3.45	2,490	0.23
Parco	8/6/25	310	4.42	1.16	0.09	0.82	0.141	4.24	1,920	0.54
		311	4.33	1.70	0.10	0.66	0.125	4.27	1,700	0.46
W. Falls	6/11/25	No melt	—	—	—	—	—	—	—	—
Shell	8/4/25	No melt	—	—	—	—	—	—	—	—

* Remelts of heat in parentheses. † Evolution Sulphurs on bars 402 to 412 inclusive. All others oxidation.

In an able paper published by Mr. F. Hudson in THE FOUNDRY TRADE JOURNAL, December 11, 1924, entitled "The Melting and Casting of High Duty Irons," the four points influencing the absorption of carbon are stated as follows:—(1) Temperature in the melting zone; (2) time in the melting zone; (3) atmosphere of combustion; and (4) initial analysis of material melted. That these are true there is no doubt, for the first two and last are special statements of the fundamental laws of solution, viz., temperature, time of contact, and concentration. The third, based on the known chemistry of the iron-carbon-oxygen system, is probably better fixed in the minds of foundrymen than the other three. The author would, however, question the restriction implied in the words "melting zone," for he is convinced that absorption can and often does continue in the hearth following exactly the laws stated above. Running only 15 per cent. steel on A B C coke he has observed a constant difference in total carbon of 0.10 per cent. when tapping intermittently as against continuous flow, the latter being about 3.50 per cent. and the former 3.60 per cent.; this on the large foundry cupolas running heats of 10 hours.

Since only the melting of steel scrap is being considered, where the original material is nearly the same in all cases, these principles may be restated as:—(1) Temperature; (2) time of contact *with carbon;* and (3) atmosphere of combustion. Looking at the problem solely from the standpoint of the coke, the case may be stated:—That the temperature depends on the purity, reactivity and size of the coke in the melting zone and below; that the time of contact depends on the purity and size of the coke, for the higher the ash the more will be the tendency to cover up the carbon by slag and prevent contact with the metal; and that the atmosphere of combustion depends on the purity, reactivity, and size of the coke. Since the reactivity depends on the purity and physical structure, and since the effective size of the coke depends on the structure, one may assume that the extent of carburisation depends on the purity and structure of the coke.

Unfortunately, the testing of coke has not reached the plane of true science, and, although it can be taken for granted that the reactivity is a function of structure, no one is yet sure of a test that will indicate the right structure for maximum reactivity. It would appear that for carburisation, coke should not be either extremely dense or extremely porous; that it should be neither too hard nor too soft; and that it should be neither very heavy nor very light. A hard, dense, heavy coke will tend to allow oxygen to persist a long distance above the tuyeres, and the molten metal will flow over a comparatively small surface of coke on its way through the melting zone, where most of the carburisation takes place.

Just as rock candy is harder to dissolve than loaf sugar, so is the dense carbon more difficult to dissolve than the light, though time of contact is probably the explanation of both. On the other hand, a soft, porous, light coke will burn almost entirely to carbon monoxide close to the tuyeres, with consequently low temperature, and it will easily crush down and either shut off the blast or blow out of the stack as did the Wichita Falls. Undoubtedly, if high temperature can be obtained with a soft, pure coke, the metal can easily be saturated beyond the eutectic. A medium structure would appear in general to give the maximum carburisation, even if temperature is somewhat sacrificed, for the highest temperatures obtained were with the Fire Creek and Barrett cokes, but neither gives the best carburisation for its class. By increasing the amount of Barrett to 35 lbs. per charge, or the same ratio as the Parco heat of 5/2/25, carbons of nearly 4 per cent. were obtained at temperatures approximating 1,600 deg.

This is not truly comparative, since 35 lbs. of Parco coke contained only 30 lbs. of carbon, and the Barrett contained almost 35 lbs., but the test is illuminating as an illustration of the effect of high temperature and greater time of contact using the same coke thus eliminating the effect of all other variables.

The melts with unbroken A B C coke show clearly the effect of the coke size on the carbon absorption. For all other tests on this cupola, the coke was carefully broken up so that no piece would stay on a two-inch screen; but in these three tests large lumps of coke, none of which would pass a two-inch screen, were used throughout and the carbon dropped 0.3 per cent. from the average for the broken coke in spite of the same temperature obtained under both conditions (1,500 deg. C.).

The experiment with Wichita Falls and A B C, 50 per cent. each, above a bed of A B C is interesting, Table II—heat of 8/29/25. Here a corrected carbon of 3.04 per cent. was obtained from the mixture, though the temperature given was rather low (1,450 deg. C.). Thus by mixing a coke (or probably pitch would be more accurate) of high reactivity with one of good structure, results may be obtained not possible with either alone.

As most of these melts were made on mild steel scrap of nondescript character and with a considerable variation in size from that desired (1 in. round), it appeared worth while to run some tests to see if ordinary variations in size had any effect on the carbon absorption. A 500 lb. length of 3.25 in. round mild steel (0.16 per cent. C, 0.06 per cent. P, 0.43 per cent. Mn, and 0.038 per cent. S) was cut into 8-in. lengths and melted (heat of 1/21/27). The next day a similar test was run with 0.75 in. round of the same analysis cut to 8 ins. The heat of 1/29/27 was run on thin strips of the same steel, varying in thickness from $\frac{1}{8}$ to $\frac{1}{4}$ in., and in width from 1 to 2 ins., as there was not sufficient of one particular size in stock to make up a complete melt. The large steel was heavier than anything used in these tests, and the thin strips were lighter than anything used in them, while the $\frac{3}{4}$ in. round would almost represent the average. It is evident that the carbon absorption does not depend on the size, for the average of the large bars and the thin strips is the same. For some reason the temperature of the $\frac{3}{4}$ in. round melt was fully 50 deg. higher than the other two, and the carbon is 15 points higher. These tests prove that carbon is not absorbed to any appreciable extent by the solid steel though the reverse may be noted on the sulphur, which seems to be absorbed much more readily by the small stuff. Another interesting confirmation of this is the melt of 8/5/25. This steel had been in the cupola for over an hour under blast, trying to melt it with the Shell coke. When the test was abandoned and the bottom dropped, the whole body of the steel was somewhere between 900 and 1,200 deg. C., but only a few pieces showed the slightest signs of melting. To test the question of carbon absorption, the author examined several of these under the microscope, finding the merest film of carbon, so it was decided to melt it with A B C coke as a further test on this point. The carbon on the melt, 2.56 per cent., is just 0.06 per cent. above the average for this coke on new steel, and is well below some other melts, so it is thought there is no doubt of the accuracy of the generalisation, which was also made by Mr. Hudson (loc. cit.).

Table III shows the equalised carbons on five melts which were remelted with slight additions of silicon and manganese, using the same coke. The metal from the first melt was largely in pigs, and therefore considerably heavier in section than the steel. The average was approximately 2 × 3 × 8 ins. with some few pieces as large as 4 × 4 ins. The original A B C heat scaffolded after the second tap, because of some rods a little too long in the charge, so that it is not truly representative of the melts of this coke, but the remelt went off in great shape. The remelt on the Dayton coke was sluggish, probably due to oxidation and high

TABLE III.

Coke.	Carbon, 1st melt.	Carbon, 2nd melt.	Carbon absorption, 2nd melt.
Dayton ..	1.80*	2.23*	0.43
Sewance ..	1.80	2.57	0.77
Bradford ..	2.81	3.33	0.52
A B C ..	2.18†	2.93	0.75
Barrett ..	3.85	4.25	0.40

* Cold melt. † Scaffolded.

sulphur, though the silicon was abnormally increased in anticipation of this result. It was difficult to get an accurate reading on it, but it was estimated that the temperature at 1,400 deg. from the cupola, which is close to the liquidus for such a low carbon.

This set of tests is to be extended for a discussion of the equilibrium point of carbon in the cupola. For this, sufficient quantitative data are not yet available, but the writer trusts they will be completed and published in the near future. There has been, perhaps, sufficient work to show that each coke tends to produce a certain definite carbon content in the melt. For a given coke this is affected by the elements other than carbon—particularly phosphorus, silicon, and manganese, and by the proportion of coke to iron and coke to blast. For the same iron and blast ratio, and the same iron composition, it will vary as the purity and structure of the coke. Thus on A B C coke, the remelt of steel 0.2 per cent. carbon reaches 2.93 per cent. and the remelt of the 4.15 per cent. pig shows 3.55 per cent. carbon (first melt 3.78. per cent.). The result from a synthetic pig of 2.95 per cent. carbon (first melt 3.30 per cent.)

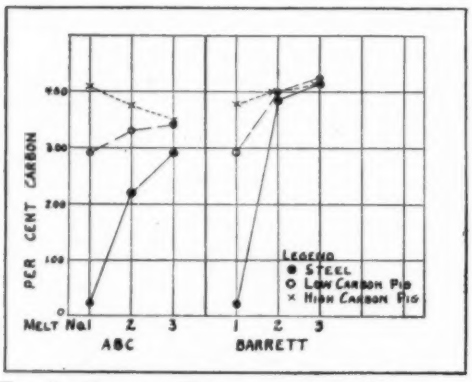

FIG. 1.—SHOWING TENDENCY FOR ALL MATERIAL TO COME TO SAME CARBON CONTENT ON REPEATED MELTING, THIS POINT BEING DEPENDENT ON COKE AND BLAST.

showed 3.46 per cent. carbon. Undoubtedly if the steel had again been remelted, the carbon would have risen again. The above values are plotted in Fig. 1 with similar results for the Barrett coke. The diagrams clearly indicate equilibrium points of 3.55 per cent. C and 4.20 per cent. C for these respective conditions. It is evident that under repeated melting the time of contact will cease to be of importance, as time equilibrium will be reached, and that the temperature and atmosphere of combustion will be the controlling factors. Aside from the effects of phosphorus, silicon, and manganese on the solubility of carbon in iron, all fairly well established, the equilibrium point for carbon will depend on the deoxidising constituents of the melt—manganese, silicon, titanium, etc.; the oxygen, carbon dioxide, and carbon monoxide content of the gas; and the temperature of the whole system. As the temperature and composition of the gas phase depend on the purity and structure of the coke, the amount of the coke, and the velocity of the blast, it is hoped that suitable tests for coke can be devised whereby the equilibrium point for the particular coke can be predetermined with fair accuracy for any given set of conditions.

In conclusion it is our privilege and pleasure to extend to the Institute of British Foundrymen the cordial greetings and best wishes of the American Foundrymen's Association, and to express the hope that we may be drawn closer and closer together by these annual exchanges of thought which are the very pledges of international goodwill.

Institute of British Foundrymen.

Sheffield Convention.

To the list of subscribers to the Sheffield Convention fund, which we published last week, there is to be added the two following names:—Messrs. Cammell Laird & Company, Limited, £15, and Messrs. Henry Wright, Limited, £1 1s.

The Continental Steel Trust.

Concerning the reduction of the penalty rate from $4 to $2 per ton for any output in excess of the German inland qouta and the retention of the rate of $4 for any excess in the export quota, it is stated that the German inland sales have been taken at 72 per cent of the allotments in the Trust and the export sales at 28 per cent. This arrangement only applies to the quarter ended with June 30, 1927; it will be the means of reducing by about one mark the ton, the extra burden imposed upon the German industry, claimed to have amounted to 2.60 mks. per ton in the March quarter. Moreover, other advantages will be derived from the fact that the actual output of steel ingots in the current year is estimated at about 17,000,000 tons, which will reduce the average costs of production.

The Polish works recently put forward a claim for an export contingent of 500,000 tons of ingots, or a corresponding tonnage of finished products. The Trust, however, made a counter proposal at 300,000 tons on condition that if the inland sales, fixed at a definite quantity, should be exceeded, the export tonnage should be reduced accordingly. It is assumed that this offer will be accepted, and that the Polish works will be granted for inland sales, not to the full extent of their claim, but for 1,200,000 tons.

The negotiations concerning the formation of international syndicates for semi-finished material and shapes have so far only met with partial success, as it has only been possible to agree to a basis for computing the quotas for a definite, extended period. At present the individual groups are occupied in ascertaining their production during a certain period. But the Belgian and French works are said to have declared from the beginning that their industries were carried on under abnormal conditions during the period selected, and that they would have to claim additions to the quotas based on statistics. Under the circumstances it is considered that some time will still have to elapse before an agreement is reached for the formation of syndicates for semi-finished material and shapes.

The Central European Iron and Steel Syndicate, which, as a group, is a member of the Continental Steel Trust, has come to an agreement with the works interested in Yugoslavia respecting prices and output. Under the agreement 30 per cent. of the inland business in Yugoslavia has been ceded to the central syndicate, thus bringing to a close the many years' contest waged by the Central European countries for the trade in the Yugoslav market.

Merchandise Marks Act.

The Board of Trade have referred to the Standing Committee (General Merchandise) applications for Orders in Council requiring indications of origin in the case of the following imported goods:—Iron and steel wire in coil, including strand wire; baling wire, cut, and looped at one end, or both; barbed wire on reels; wire nails and wire staples; also products of the above.

Representatives of any interests substantially affected by any of these applications who desire to be heard in opposition at the inquiry are requested to communicate with the secretary to the committee, Mr. E. W. Reardon, at the New Public Offices, Great George Street, London, S.W.1, with the least possible delay, and, if practicable, not later than July 15.

The Standing Committee will hold their inquiry next week as to whether the undermentioned classes and descriptions of imported goods should bear an indication of origin as follows:—Brass water taps and other water fittings of brass, and brass parts thereof; cabinet furniture of metal (not including locks); furniture castors, electric lamp holders, wall plug switches, and similar household fittings and metal parts thereof; brace and belt buckles of metal. The inquiries will be held in Room 76, first floor, New Public Offices, Great George Street, London, S.W.1. Any communication on the subject should be addressed to the secretary, Mr. E. W. Reardon.

WE ARE INFORMED by Vickers, Limited, that Mr. F. Dudley Docker, the Rt. Hon. R. McKenna, and Sir William Plender, Bart., have notified the board of Vickers, Limited, that in their opinion the time has arrived when they can properly relinquish their position as advisers to the board, which position they were invited to occupy at the request of the board and with the approval of the shareholders, at the time of the reconstruction of the company. In accepting their resignation, the board have taken the opportunity of acknowledging, on their own behalf and that of the shareholders whom they represent, their sincere appreciation of the great services which they have rendered to the company in an honorary capacity. Mr. George R. T. Taylor has been elected deputy-chairman of the company.

The Manufacture of a Large Steel Casting.*

By F. A. MELMOTH and T. W. BROWN.

The writers propose in the following Paper to outline the complete history of the production of a large steel casting, and have chosen as their subject the case of a cast steel propeller shaft bracket. They propose to deal with each of the operations entailed in its production, both metallurgically and from the moulding shop standpoints, and to express their reasons for the choice of any particular method where alternatives exist.

The production of any steel casting falls naturally into the performance of the following operations, taken in their order of sequence:—(1) The manufacture of the necessary steel; (2) the preparation of the sand; (3) the making of the mould and cores; (4) the actual casting of the job; (5) the annealing; (6) the fettling, and (7) inspection and testing.

It is not the intention of the writers to deal with the making of the pattern, and it is assumed for the purpose of the Paper that this is provided. Fig. 1 shows the pattern as received ready for work in the foundry.

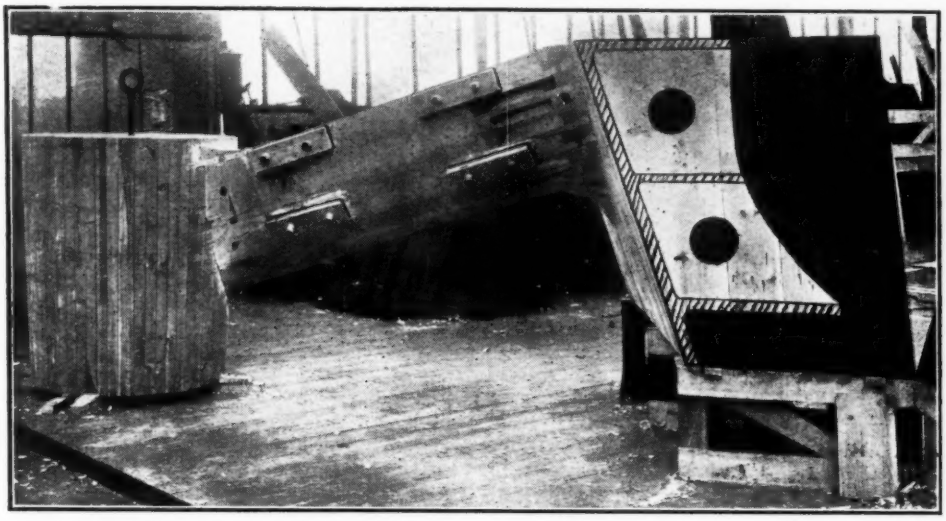

FIG. 1.—PATTERN AS RECEIVED.

The Manufacture of the Steel.

The processes open to the steelmaker which are capable of producing steel suitable for the job under discussion are three in number:—(1) Siemens open hearth; (2) converter; and (3) electric. The main points appertaining to each process are appended.

Siemens Open Hearth.

In this process the necessary pig-iron and scrap steel to constitute a satisfactory composition in the molten charge are melted together on either an acid or basic hearth, this depending on both the composition of the materials available and also the nature of the desired product.

In the case of the acid hearth, the existence of a necessarily acid slag permits no possibility of refinement where sulphur and phosphorus are concerned, and, therefore, the raw material used must be of the required degree of purity in these two elements. The basic slag used on a furnace equipped with a basic lining, however, aids the possibility of the abstraction, during the process, of a certain amount of these elements, and, therefore, a greater degree of latitude can be allowed in their existence in the original scrap and pig-iron. In this country, acid lining is the more popular, and has been developed to a much greater extent, due probably to the ease with which low sulphur and phosphorus pig-irons can be obtained, and partly due to the generally accepted idea of the superiority of the resulting steel when made by the acid process. The writers do not feel qualified to deal with any serious discussion on the question of this superiority, but there seems little doubt but that the acid process is the more popular and probably the more consistent in its product, whilst possessing in a marked degree an elasticity which makes the production of a wide range of compositions of steel an every-day occurrence.

Procedure When Making a Steel Casting.

The scrap and pig-iron are melted down as quickly as possible, and also as hot as possible. To the resulting molten bath, iron ore is added, which through the agency of the slag oxidises manganese and silicon with their consequent removal to the slag. These elements being removed, the iron ore acts directly upon the carbon present, removing it in the form of carbon monoxide gas, which, escaping in bubbles through the layer of slag, causes the well-known phenomena known as the "boil." This is continued by the addition of the necessary amounts of ore or limestone, or both, until such times as the carbon content is reduced to the neighbourhood of the required figures.

During the whole of the process, the direction of the gas and air through the regenerating chambers and the furnace is frequently reversed, thus building up continually the initial temperature of the incoming gases, with a consequent increase in the temperature produced by their combustion. The slag being in the correct condition, the temperature sufficiently high, and the carbon content near to the required figure, de-oxidising alloys, ferro silicon and ferro manganese, are added to the bath in calculated amounts to remove active oxide, and leave in the steel the amounts called for in the specification. The steel is then tapped into the ladle and poured in the usual way.

The writers recognise that this is an extremely sketchy description of what is in itself a highly skilled and complicated process, but the scope of such a Paper as the one now submitted will not allow of a detailed description of any steel-making process.

Main Characteristics of Siemens Open Hearth Metal.

(1) It can be produced in large charges, and is, therefore, ideally adapted for large, heavy castings; (2) it is under complete control both chemically and in temperature, and therefore specification work can be rigidly adhered to; (3) the temperature obtainable being on the low side as compared with electric or converter processes, coupled to the fact of the large charges usually made,

* A Paper read before the Sheffield Convention of the Institute of British Foundrymen.

makes the process not so suitable for small work; (4) produced under properly controlled slag conditions, the steel is remarkably free from non-metallic inclusions, and is of consistently high quality; and (5) the process is capable of satisfactorily producing quite a wide range of alloy steels.

The Converter Process.

In this process a quantity of molten cast iron, previously melted in a cupola, is subjected to the oxidising action of a blast of air. The air can be applied either from the bottom, thus passing through the molten metal, or at the side. In either case, the process of operations is identical. The manganese and silicon, and finally the carbon, are oxidised by the air, with the production of a great amount of heat. The blown metal is therefore raised to such a high temperature that, after the addition of the necessary de-oxidisers at the termination of the blow, it is sufficiently hot and fluid to cast the lightest of sections.

No refining is possible from the point of view of sulphur and phosphorus content when the vessel is acid lined, which is the usual practice in this

FIG. 2.—MOULD READY FOR CLOSING.

country. It must be remembered, therefore, when selecting the irons used for this process that an increase, particularly of sulphur, will occur due to the cupola melting prior to the blowing operation.

Advantages of the process are:—(1) The steel is extremely hot and possesses in a high degree the property of fluidity, so valuable to the maker of light castings; and (2) the very rapid production of the steel compared with any other process inevitably means some reduction in cost, and is of great assistance particularly where repetition production methods are in progress.

The disadvantages are:—(1) The steelmaker is at the mercy of his scrap and pig-iron supply, as no refining is possible; (2) the vital point at the termination of the blow can only be determined consistently after considerable practice, and the regularity of the required compositions is, therefore, not so great as is the case in either open-hearth or electric processes; and (3) the total weight per charge is limited, and is usually insufficient for heavy castings. This necessitates blowing more than once when a heavy casting has to be made with consequent risk of trouble and failure.

The Electric Process.

From the point of view of reliability and consistently high quality, the production of steel from electrically operated furnaces has met with almost universal approval. Although the latest comer into the foundry field, its merits have won for it a high place as a means of satisfying the somewhat exacting steel requirements of the modern foundry.

Furnaces are available either basic or acid lined, and in the case of the former the composition of the scrap material used is, within wide limits, almost negligible. By correct slag manipulation, impurities can be removed almost to traces, and the simplicity of the process makes it easily possible to produce steels of almost any composition with great regularity. It is admitted that the future of the furnace for such steels as are the normal products of a foundry, depends greatly on a cheap supply of electric power.

A Typical Charge.

It is assumed that the scrap or turnings available are of medium quality, and that a certain amount of refining is necessary to bring sulphur and phosphorus within the specification limits.

The scrap and turnings are charged on to the hearth in the order named, the obtaining and maintaining of a steady arc being more easily effected on the turnings than would be the case were an arc to be struck on bulky masses of scrap steel. By bringing the electrodes into close proximity to the charge, an electric arc is formed between the electrodes and the metallic charge. This arc is maintained as continuously as possible, by the careful regulation of the distance between electrodes and charge, until such time as pools of liquid metal are formed under the electrodes.

From this point the control of the load becomes an easier matter, and after the addition of the required amount of lime to form a covering slag, the power input is maintained at as high a figure as possible until the charge is practically completely melted. Any small amounts of unmelted metal adhering to the banks are then pushed into the bath.

The scrap and turnings commonly possess a sufficient covering of rust to make it tolerably certain that when melted, almost the whole of the carbon, silicon and manganese will have been oxidised. The slag will be definitely oxidising at this point, and in these conditions phosphorus is removed by oxidation from the molten bath and passes to the slag. The removal of this slag, therefore, at this point, ensures that refinement in this element is established. Melting by this method, and with no special additions to maintain a high carbon on melting, the composition of the metal at slagging will probably approximate the following:—Carbon 0.06, Silicon 0.04, Manganese 0.08, Sulphur as charged, and Phosphorus 0.015 per cent.

It will be seen, therefore, that sulphur is the only ordinary element remaining unaffected up to this point. This is due to reducing conditions being a necessity for the removal of sulphur, whereas the former oxidising conditions only satisfactorily accounted for the carbon, silicon, manganese and phosphorus. The reduction of sulphur being desired, it is necessary, therefore, for the oxidised character of the metal to be now removed. A new slag is formed by the addition of lime and fluorspar, the latter lowering the slag fusion point and quickly giving a fluid covering of slag to the metal. The oxidised condition of the bath is removed by small successive additions of ferro-silicon, and at the same time the character of the slag is rendered somewhat reducing by small quantities of crushed anthracite or coke. A continuance of this will produce a steel free from wildness, and under the reducing slag sulphur is removed from the steel, passing into the slag as a sulphide. Carried to the point of what may be termed super-refining, the slag will, on cooling, definitely fall to a greyish powder.

Tests are taken both for analytical purposes and for temperature, the required additions of ferro-silicon and ferro-manganese, etc., are added to the furnace and the steel poured into the ladle.

Where a high degree of freedom from sulphur and phosphorus is not called for charges can be made quite satisfactorily under one slag only, and it is the opinion of many experienced steel makers that made thus, electric steels possess an increased degree of fluidity, making them much easier to handle in the foundry. Economically, however, very great advantages exist in single slag working as total time per charge is lessened, heat losses during the slagging period are avoided, and slag materials are used in less quantity.

The liability to dangerous variations in the quality of the raw material, more particularly the turnings, makes it somewhat risky, however,

to adopt single slag working, unless the origin of the scrap and turnings is definitely known and controllable.

From the rather meagre outline of these processes, perhaps sufficient can be gathered to appreciate their applicability to such a job as the

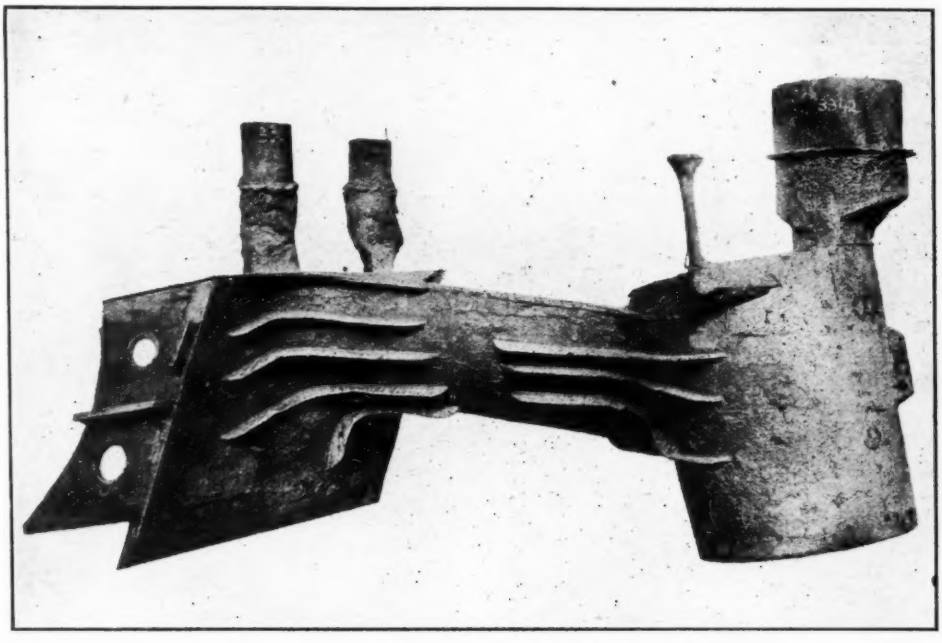

FIG. 3.—CASTING AS RECEIVED IN FETTLING SHOP.

casting which forms the subject of this Paper. In the first place, a converter was not available in the particular shop in which the casting was made. As about 12 tons of steel was needed to cast the job satisfactorily, the writers would, in any case, have hesitated to use the process.

between open hearth and electric steel, both of which were available in ample quantities to cast the job. From the point of view of general suitability, the writers are of the opinion that either would give satisfaction, always with the proviso that pig-iron and scrap of known high quality were used in the open-hearth furnace. Economically, the balance is definitely in favour of the open-hearth process by which steel can be produced at present at a lower figure than by electric methods.

Circumstances at the time of casting, however,

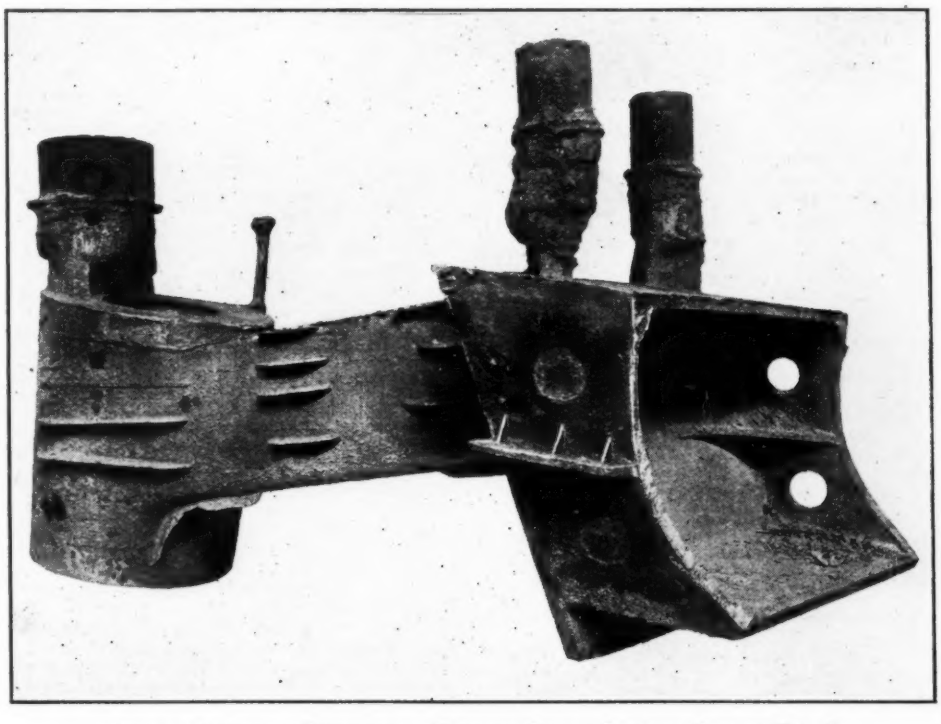

FIG. 4.—CASTING AS RECEIVED IN FETTLING SHOP.—OPPOSITE SIDE TO FIG. 3.

Quite apart from the difficulties associated with blowing twice for the one job, the specified tests were of such a high order that nothing but steel of the very highest quality could be contemplated.

It therefore resolved itself into a decision

made it necessary to use electric steel for this casting, and in considering test results, etc., it should be remembered that they represent those obtainable from such a casting made from basic electric steel.

Composition of Steel.

Having decided on process, the question of composition requirements now only remains to be dealt with. In considering this, the physical requirements demanded by the inspecting authorities are naturally the controlling factor. For this class of work the test requirements are normally as follows:—Maximum stress 28-35 tons per sq. in., yield point 14-18 tons per sq. in., elongation 20 per cent. minimum, and bend (cold) 90 deg. on 1 in. square.

The influence of the various elements on the physical test results of the annealed casting is as follows:—

Carbon.—Increases maximum stress with increasing quantity, and coincidently reduces ductility, and therefore elongation and cold bend results.

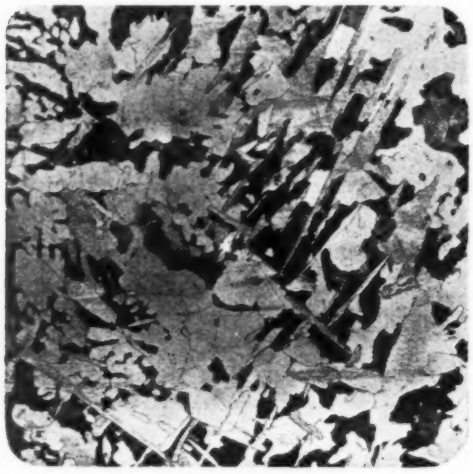

Fig. 5.—Steel Casting as Cast × 50.

Silicon.—No appreciable effect in the normal quantities found in commercial mild steel for castings. Is present almost entirely as a deoxidiser to ensure soundness.

Manganese.—Tends to increase maximum strength and yield point, without seriously affecting the ductility if present in the usual amounts. Over 1.2 per cent. tends to reduce elongation to some extent. Is also an effective deoxidiser, and assists soundness very considerably.

Fig. 6.—Steel Casting as Cast × 200.

Sulphur.—An accidental impurity, and detrimental in many ways if in excess—0.05 to 0.06 per cent. being looked upon as upper safe limits. In excessive amounts induces red shortness, and may be the cause of cracks and tears by causing intercrystalline weakness. The amount of manganese present acts as a partial corrective, by forming manganese sulphide, and thus preventing the formation of the extremely detrimental sulphide of iron. From all standpoints best kept within low limits. Maximum stress, yield point, elongation and bend are all badly affected by excess.

Phosphorus.—This element is regarded with great suspicion by steel founders, owing to its tendency to produce cold shortness when in excessive quantities. Maximum stress and elongation may be but little affected after annealing, but impact tests may be badly affected. The safe upper limit is regarded to be 0.05 per cent. to 0.06 per cent.

Bearing in mind the previously mentioned test requirements, and the effects of composition in the various elements above described, it was decided to make the steel to the following:—Carbon, 0.25 to 0.30; silicon, 0.15 to 0.25; manganese, 0.6 to 0.7 per cent.; sulphur, low; phosphorus, low.

This was produced in an electric furnace of the necessary capacity, and the resulting material analysed as below:—Carbon, 0.26; silicon, 0.18; manganese, 0.56; sulphur, 0.017; and phosphorus, 0.022 per cent.

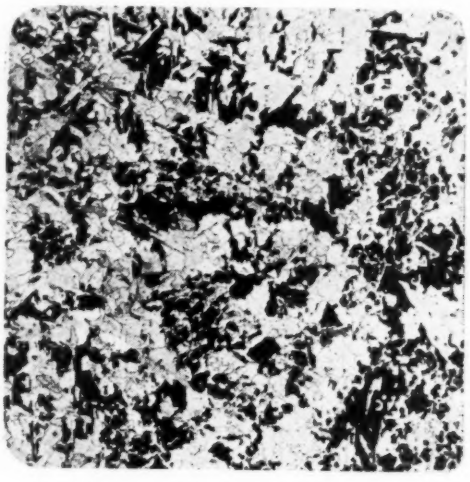

Fig. 7.—Steel Casting Annealed × 50.

(To be continued.)

Goods by Rail: A Hint.

In the search for ways of effecting new economies it would, we are confident, well repay many business firms to look into the question of distributing their goods, upon a larger scale than at present, from railway depôts. A Midlands company known to us now makes a saving of nearly £150 per annum by this means. Regularly sending many small but heavy articles to a certain town, they have been in the habit of having the goods delivered in each case direct to the consignee. The railway company itself, however, last year pointed out that if they, the consignors, took the step of renting small warehouse spaces at certain of the railway's local goods depôts—some half-dozen places, which were named—the charge would be more than covered by the saving that would follow in the cost of delivery. Most railway companies are now willing to allot quite small spaces—in the case in question, two were under 15 yards square—at a cost of 10s. per month in London and 8s. 9d. per month in the provinces. We do not doubt but that a great many firms, to whom, perhaps, the service prepared to be rendered by the railways in this connection is not very well known, would easily be able to save the cost of the rent of such depôts—a mere half-crown or two shillings per week—over and over again. A further point is that, where the consignments are too small in number or too low in value to justify a firm's having their own man on the spot to attend to distribution from the local depôt, the railways now, or most of them, are prepared to undertake the work on reasonable terms.

At the Ninth Annual Conference of the Association for Education in Industry and Commerce, held in London last week, the new President (Sir David Milne-Watson, LL.D., D.L.), in his presidential address, dealt with "Education and Industry." The main subject of discussion at the conference was "The Recruitment and Training of Young Employees in Industry and Commerce."

The Influence of Manganese and Manganese Sulphide on Whiteheart Malleable.*

By E. R. TAYLOR, A.R.S.M., D.I.C., F.I.C.

Much has been written from time to time on the question of manganese, sulphur and manganese sulphide in cast iron and steel, but there is not a great deal of published information on the effect of these constituents on whiteheart malleable.

It is generally agreed that the injurious effect of sulphur in ferrous alloys may be neutralised very considerably by the presence of manganese. When manganese and sulphur combine to form manganese sulphide, 32 parts of sulphur combine with 55 parts of manganese to form 87 parts of manganese sulphide, so that one part of sulphur requires $\frac{55}{32}$ or 1.72 parts of manganese. It is well known, however, that the formation by manganese and sulphur of manganese sulphide is rarely, if ever, completed when iron and carbon are present, since other combinations may and in fact do take place. Assuming for the moment that in a particular case manganese and sulphur are present in an iron in the atomic proportions mentioned above, *i.e.*, 172 parts of manganese for every 100 parts of sulphur, not all the 272 parts of manganese sulphide would be formed, as some of the sulphur would combine with the iron to form ferrous-sulphide; alternatively some of the manganese may combine with carbon to form manganese carbide. According to the law of mass action, the tendency of a given amount of sulphur in the presence of manganese to form nothing but manganese sulphide will be assisted if the concentration of manganese (that is the amount of manganese present) is increased. If, therefore, it is desired to secure the greatest possible amount of sulphur as manganese sulphide, or as a compound sulphide containing the greatest possible amount of manganese, the amount of manganese must be increased much beyond that demanded by the theoretical ratio. In other words, an excess of manganese is required, and the greater this excess the larger will be the proportion of sulphur combined with manganese.

In ordinary grey-iron castings manganese is invariably preferred in excess of the theoretical ratio needed to convert sulphur to manganese sulphide. The excess of manganese over the theoretical demand of sulphur will be referred to as "excess" manganese, and clearly the greater the amount of "excess" manganese the larger the proportion of sulphur combined with manganese. The writer does not desire to refer, in connection with this Paper, to controversies with respect either to the precise influence of manganese on cast iron, the differentiation of sulphides under the microscope, or the possibility of sulphides of iron and manganese existing as compounds. He merely desires to point out that in cast iron it is generally recognised that sulphur exists best combined with manganese, and to ensure the maximum proportion of sulphur so existing, manganese is used in excess of that theoretically required.

In mild steel the sulphur is usually not over 0.05 per cent., and the manganese is ordinarily about 0.5 per cent. In the recent Report on the Heterogeneity of Steel Ingots,† it is stated that:—"When manganese is added to the steel in the bath, the distribution of the sulphur between the two elements iron and manganese is determined by the relative amounts of the two metals present and their respective affinities, and the sulphide is always of a complex character (FeMn)S. It is generally accepted that this complex is insoluble in liquid iron, and its distribution is governed by a different law from that of the other constituents. In addition, there is no doubt that this sulphide is of lower density than liquid iron."

Ordinary text-book literature repeatedly conveys the impression that an excess is preferred to a deficiency of manganese, and numerous references could be given to scientific Papers to the same effect.‡

Whiteheart Malleable Pig Iron.

In whiteheart malleable pig-iron the silicon content is low. Unavoidably, under present conditions of blast-furnace operation, therefore, the sulphur present is high, considerably in excess of what is obtained in foundry pig. The growth of cupola melting of whiteheart malleable naturally emphasises the sulphur difficulty owing to the absorption of sulphur from the coke. The chilling effect of sulphur is well known, and in the absence of manganese the sulphur would clearly retard the annealing operation. Furthermore, there would be practical difficulties in the way of securing a predetermined sulphur content, which would make any systematic control, by means of sulphur, difficult if not impossible, small changes in the sulphur content producing marked differences of the structure. The question of the desirable manganese content in whiteheart malleable is therefore of practical importance, as manganese in removing some sulphur takes from the metal a carbide-stabilising agent of great power. The intrinsic influence of manganese, apart from sulphur, on the carbide is still disputed, but metallurgical opinion as a whole takes the view that manganese also stabilises the carbide. Thus it would retard annealing, and if this view is correct the removal of manganese and sulphur deprives the metal simultaneously of two hardening agents. The problem would be simple if the formation of manganese sulphide were complete and non-reversible. An excess of manganese is necessary, and it may be assumed that this excess is present in the metal as manganese carbide. The question then arises—is it preferable to remove the maximum quantity of sulphur by excess manganese, or should the manganese be limited? In other words, which is the greater evil to the malleable founder, manganese carbide from excess manganese or ferrous sulphide from sulphur not combined with manganese, both of which may retard annealing? What middle course, if any, is open?

Purchasers of whiteheart malleable pig-iron have the choice of material from various localities, and the sulphur contents differ very widely. The writer has found such pig as high as 0.65 per cent. in sulphur, with traces of manganese, while at the other extreme irons with a much higher manganese content gave only 0.12 per cent. sulphur. In view of these variations there is therefore a good deal to be said for the practice of mixing and remelting these irons into so-called refined pig-iron before they reach the malleable founder, as this permits a predetermined ratio of manganese to sulphur.

The final question that arises, assuming that for whiteheart malleable a desirable ratio of manganese to sulphur could be fixed, may be stated as follows. Is there any difference between irons of differing sulphur contents? In other words, could a high-sulphur pig be utilised as satisfactorily by the industry (provided it contains its quota of manganese) as a low-sulphur pig with its proper manganese ratio? Can manganese sulphide be regarded as neutral from the point of view of its effect on the properties of whiteheart malleable?

Sulphur and Manganese in Black Heart.

In a Paper given by Professor Enrique Touceda before this Institute, at the Birmingham Conference in 1922, the question of manganese and sulphur in black heart was discussed. He said:—"The question, then, really resolves itself into what are the permissible limits for the sulphur and manganese. While it is generally conceded that these elements should be present in atomic

* Paper presented to the Sheffield Convention of the Institute of British Foundrymen.

† "Journal of the Iron and Steel Institute," No. 1, 1926, p. 39.

‡ See E. R. Taylor, "Carnegie Scholarship Memoirs," Vol. 15, 1926, pp. 382 and 406.

proportions to form manganese sulphide, the author has seen many instances in which the product was excellent where this was not the case. Based upon data obtained from the testing of many test bars, the author would state that with a sulphur content between the limits of 0.05 and 0.08 per cent. it is safe to use a manganese content between the limits of 0.20 to 0.30 per cent., with recommendation to avoid using, coincidentally, the high limit for manganese with the low one for sulphur, and contrariwise. The manganese should be increased with increasing sulphur, and with the latter at 0.12 per cent. it should lie between 0.34 and 0.40 per cent."

Professor Touceda also refers to cupola-melted black heart in which sulphur averaged in the casting 0.25 and manganese 0.6 per cent., this being used for fittings in which superiority in quality is not essential. It was pointed out by him that this metal would show abnormal structure in heavy sections, and be low in elongation. It might fairly be concluded from these remarks that poor ductility may be attributed to the presence of manganese sulphide.

Dr. W. H. Hatfield,* in discussing black heart malleable, says:—"The manganese in the black-heart material is there to neutralise the sulphur, and this content should largely be determined by the content of the latter element."

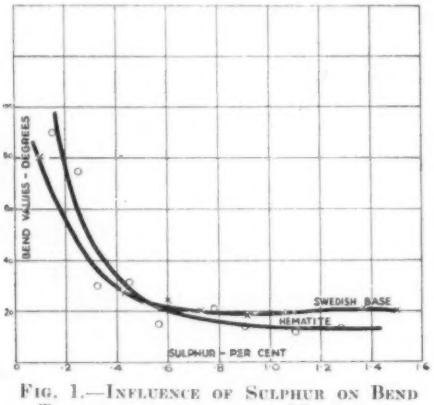

Fig. 1.—Influence of Sulphur on Bend Test in the Absence of Manganese.

Influence of Sulphur in Whiteheart Malleable.

The author first determined the influence of sulphur in whiteheart malleable. This material may be regarded as an impure iron-carbon alloy, and in order to ascertain the influence of sulphur in the absence of all elements other than iron and carbon, a Swedish iron base was used, to which 11 per cent. ferro-silicon was added to secure a uniform silicon content throughout the series, of 0.6 per cent., together with ferrous-sulphide to give varying sulphur contents throughout the series. At the same time a second series was made up, using as a base hematite iron of the kind commonly used in the trade, but of high sulphur and low manganese content, silicon being kept the same as before. Tensile and bend bars were cast in green sand, B.E.S.A. standard bars being employed.† In the chemical analyses sulphur was always determined gravimetrically. The details of the analyses of the original Swedish white iron and of the subsequent mixtures made up, before and after annealing, are given in the original Paper,‡ together with those of the series made from the hematite iron. The Swedish iron contained 3.10 per cent. total carbon, and 14 melts were made up, the sulphur varying between 0.019 and 1.49 per cent. The hematite iron contained 2.9 total carbon, 0.70 silicon, 0.65 sulphur, 0.03 per cent. manganese, and 10 melts were made up with sulphur varying between 0.151 and 1.28 per cent., the lower sulphurs being secured by Swedish iron additions.

The bars were annealed under commercial conditions at the works of the Incandescent Heat Company, Limited, Smethwick, by courtesy of Mr. J. J. Fallon. The ore ratio employed was 1:3, the annealing period being 125 hours, of which 60 hours was between 890 and 960 deg. C. This annealing cycle is not ideal, being too short at the top temperature, and the cooling being too rapid. The influence of sulphur on tensile strength was shown to be wholly deleterious in both series. In the Swedish series the ultimate tensile strength fell from 24 tons per sq. in. for 0.1 per cent. sulphur, to 8 tons per sq. in. for 1.5 per cent. sulphur. The B.E.S.A. specified figure was maintained with sulphur under 0.5 per cent. The elongation figures for both series were disappointing, due to rapid cooling. In the hematite series the ultimate tensile strength was 23.5 tons per sq. in. at 0.15 per cent. sulphur, falling to 10 tons per sq. in. for 1.28 per cent. sulphur. The B.E.S.A. figure was maintained under 0.7 per cent. sulphur. The influence on the bend test is shown in Fig. 1. For complete details of the mechanical tests the reader is referred to the original Paper.

With the adoption of a commercial silicon content, the main difference between the Swedish and hematite bases, in view of the low manganese content of the latter, was that of sulphur, which was, of course, varied deliberately in the melts made up. It might be anticipated, therefore, that there would be little difference between the results of the two series, and this is confirmed by Fig. 1.

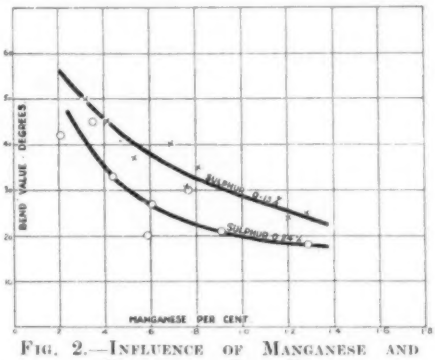

Fig. 2.—Influence of Manganese and Sulphur on Bend Test.

Conclusions.—For the Swedish series both tensile strength and elongation diminish with increasing sulphur. The elongation figures on this series were unduly low, doubtless owing to the rapid cooling from the furnace and short annealing. The bend test is below the specified figure at over 0.3 per cent. sulphur.

The hematite series afford a more satisfactory basis for comparisons with commercial material. Again mechanical properties diminish regularly with increasing sulphur, and the bend test shows that sulphur over 0.3 per cent. is below specification. Sulphur, therefore, exercises a wholly deleterious influence on the properties of whiteheart malleable when manganese is absent.

(To be continued.)

* Journal of the Iron and Steel Institute, 1917, p. 319.

† See B.E.S.A. Specification 5022 (1923), on whiteheart malleable for automobile castings. The ultimate tensile strength specified is 20 tons per square inch with an elongation on 2 inches of 5 per cent., and a bend of 45 degrees round a 1 inch radius. The same figures have been proposed for the tentative specification for general whiteheart malleable, although there are slight changes in the test pieces and test conditions.

‡ See E. R. Taylor, "Carnegie Scholarship Memoirs," 1925, p. 131.

Company Reports.

Davy Brothers, Limited.—Loss for twelve months, £34,929; debit balance brought forward, £7,810; a debit balance carried forward, £42,739.

Carnforth Hematite Iron Company, Limited.—Net loss for 1926, after payment of debenture interest, £31,004, increasing debit brought forward to £197,809.

Ransomes & Rapier, Limited. — Report for 1926 shows a loss of £12,054; preference dividend, £746, and charging remaining debit to the credit brought in a credit balance of £10,431, which it is proposed to carry forward.

General Electric Company, Limited. — Profit, £1,030,853; brought in, £310,623; available, £1,341,477; after deducting debenture interest, depreciation, £195,611; pension fund, £18,344; dividend, 6½ per cent. per annum on the "A" preference for year, 7½ per cent. per annum on the "B" preference for year, reserve £140,000, and 7½ per cent. on the ordinary.

Reduce YOUR Fuel costs

BY 30 to 50 PER CENT

Instal the Poumay System

and pay for it out of the savings effected in the first year's working!

The Poumay System of cupola control ensures a practically PERFECT COMBUSTION. All the useful gases being burnt in the cupolas. No oxidisation occurs because the minimum quantity of air is used.

THE POUMAY SYSTEM IS RESPONSIBLE FOR :—

1. Very pure metal at a very high temperature.
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3. 30%—50% fuel reduction.
4. A very rapid melt.
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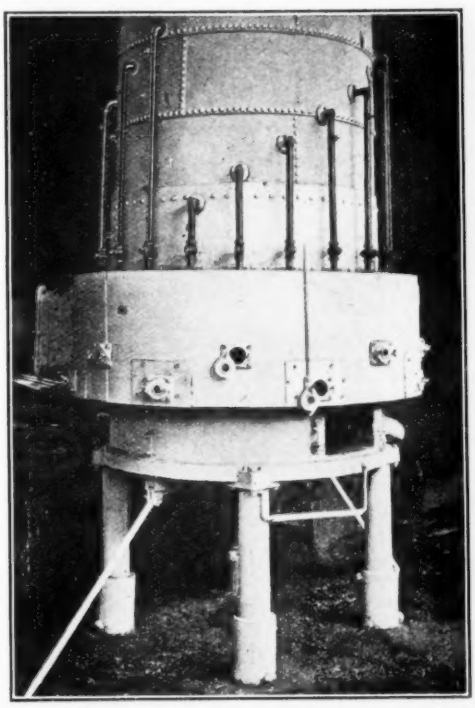

Read what these satisfied users of the Poumay System say :

KRYN & LAHY METAL WORKS, LTD.,

Steel Founders and Engineers, **LETCHWORTH, HERTS.**

"We have pleasure in stating hereby that we are quite pleased with the results we have obtained up till now from our two cupolas which we have transformed according to the Poumay system.

"Our cupola No. 1 was transformed at Easter and was started on the 20th April

"Our cupola No. 2 was transformed at Whitsun and was started on the 8th June.

"We melt, in these cupolas, a mixture of 75% steel scrap and 25% hematite pig-iron.

"Before the installation of the Poumay system our melting coke consumption averaged 13% to 14% of the metallic charge. We have now brought it down to 9% to 9½%, and the temperature of the metal as tapped from the cupolas is quite as high as it was before.

"This means an economy of over 30% on our previous coke consumption, in addition to which we find a considerable reduction in the sulphur content of the metal.

"Moreover we are melting much faster than previously and are getting regularly 5½ to 6 tons per hour from each cupola as against 4½ to 5 tons before."

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Trade Talk.

FIVE SHEET MILLS at the works at Pontardawe of W. Gilbertson & Company, Limited, restarted on June 27 after several weeks' idleness.

A. DAVIS & COMPANY, ironfounders, Woodlands Street, Smethwick, have removed their business to more extensive premises at the Tipton Foundry, Albion Street, Tipton.

THE RUMOUR that the National Light Castings Ironfounders' Association had been broken up is incorrect. It appears that there was some dissatisfaction on the part of the merchants as to the terms being allowed to them, but a new scheme has now been put into operation, and it may be that this was responsible for the rumour referred to.

MR. G. F. BARWICK, of the Association of Special Libraries and Information Bureaux, points out to contributors that certain information in connection with the preparation of the "Directory of Sources of Specialised Information" is still required, although the compilers are fast approaching the close of their work. Details of further collections in the possession of private individuals are invited.

UNDER THE Lead Paint (Protection against Poisoning) Act, 1926, the Home Secretary was empowered to make Regulations for preventing danger from lead paint to persons employed in or in connection with the painting of buildings. Draft Regulations were issued in the early part of the year, and a considerable degree of agreement was arrived at between the Home Office and the various organised bodies in the building and decorating trades. There were, however, objections from certain other quarters, and accordingly a public inquiry was ordered. Sir William Mackenzie, K.C., was appointed the Commissioner for this purpose, and he held the public inquiry at the Central Hall, Westminster, London, on Wednesday and Thursday, June 22 and 23.

ON JUNE 29 the Prince of Wales was in Barrow and visited the works of the Barrow Hematite Steel Company, Limited. He watched a furnace being tapped and then went through the steel departments and saw the rolling of steel rails. Later he went to the shipyard of Vickers, Limited, where he saw through the engineering shops and the shipyard. At the steel works he was received by Mr. G. Mure Ritchie, the chairman of directors, and at the shipyard by Commander Sir Trevor Dawson, R.N., chairman of the Armaments and Shipbuilding Board, and by Commander C. W. Craven, R.N., managing director of the Barrow works. The visit of the Prince concluded with the opening of the Infield Convalescent Home. This was given by Vickers, Limited, a subscription of £10,000 also being raised in the town for equipment and maintenance.

MR. A. DE V. LEIGH, secretary of the London Chamber of Commerce, 1, 2 & 3, Oxford Court, and 97, Cannon Street, London, E.C.4, writes that the attention of the Chamber has recently been drawn to a case where a member has sustained considerable loss owing to the faulty assay of a parcel of Chinese tin at the Hongkong Government Laboratory. The terms of the contract on which the parcel was bought stipulated that this assay should be final, but on re-assay in this country the metal showed only 98.80 per cent. Sn. instead of the 99 per cent. Sn. certified by the Hongkong Laboratory. It is desired to ascertain whether the above may be regarded merely as an isolated instance or whether errors at the Hongkong Laboratory are of sufficiently frequent occurrence to justify a recommendation to the trade that they should in future include a provision in their contracts for re-assay, in case of dispute, by an independent and authoritative body on this side. Representations have already been made without success to Hongkong, and Mr. A. de V. Leigh is invoking the opinions of the members of the Iron, Steel, Tinplate and Metal Merchants' Section of the Chamber as to whether they consider further action might be taken in the matter.

Contracts Open.

Bristol, July 11.—Single-face sluice valves, with hydraulic cylinders, for new sluiceway, for the Port of Bristol Authority. Mr. T. A. Peace, chief engineer, Avonmouth Docks, Bristol. (Fee £3, returnable.)

Calcutta, July 11.—(No. N. 6.419) Electrical substation plant and equipment, for the Indian Stores Department, Simla. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. B.X. 3,581.)

Coupar Angus, July 8.—600 yards 5-in. iron water pipe, with the necessary connections, for the Town Council. Mr. J. A. R. Macdonald, burgh surveyor, Town Buildings, Coupar Angus.

Obituary.

THE DEATH TOOK PLACE recently of Mr. David Bruce Craig, head of the firm of D. Craig & Sons, ironfounders, Millerhill, Midlothian. Mr. Craig, who was in his 73rd year, specialised in particular in castings for paper mills and the mining industry.

MR. P. MACLEOD BAXTER, M.I.N.A., M.I.Mech.E., who was formerly head of the firm of M'Kie & Baxter, engineers, Glasgow, died recently at his residence, 7, Bute Mansions, Glasgow. Mr. Baxter retired from active service when the firm was formed into a limited liability company last February. He was 62 years of age.

WE REGRET to announce that Mr. W. F. Eagland, one of the original proprietors of THE FOUNDRY TRADE JOURNAL, "The Iron and Coal Trades Review," and "Rylands Directory," and a director of Industrial Newspapers, Limited, the present proprietors of these journals, died last Friday morning, at Epsom.

New Companies.

D.W.L. Syndicate, Limited, 25, Bond Street, Leeds.—Capital £1,000 in 6d. shares (15,000 10 % part. pref. and 25,000 ord.). To carry on the business of engineers, factors, and dealers in liquid fuel burners, liquid fuel-fired furnaces, furnace builders, miners, metallurgists, etc.

C. E. Faulkner, Limited, 57, Bishopsgate, E.C.2.—Capital £1,000 in £1 shares. Iron, steel and metal merchants, etc. Directors: C. E. Faulkner (permanent governing director and chairman), 2, Lansdowne Place, S.E.10; and Mrs. J. F. N. Faulkner.

Harrison & Camm, Limited.—Capital £20,000 in £1 shares. To acquire business carried on by Harrison & Camm, Limited, at Rotherham Wagon and Wheel and Axle Works, The Holmes, Rotherham.

Jackson Bros. (Milton), Limited.—Capital £3,000 in £1 shares. To acquire business of aluminium, gunmetal, phosphor bronze and ironfounders, carried on by S. R. Jackson, A. E. and T. D. Jackson, at Milton, Staffs., as Jackson Bros.

L. Tomey, Limited.—Capital £2,000 in £1 shares. Brass casters, etc.

George Wearing, Limited, Carters Green Foundry, West Bromwich.—Capital £5,000 in £1 shares. Iron manufacturers.

Company Meeting.

Ruston & Hornsby, Limited.—Presiding at the annual meeting of Ruston & Hornsby, Limited, Lincoln, held on June 20, MR. J. S. RUSTON said the associated company of Ransomes, Sims & Jefferies, Limited, of Ipswich, in common with other engineering concerns, had not had a successful year, and their directors did not feel justified in recommending the payment of any dividend on the ordinary shares. With regard to their own company, the directors regretted that the improvement experienced in the previous financial year had not been maintained, due to the abnormal conditions arising out of the strike in the mining industry. The business had suffered a setback in consequence, and the directors greatly regretted they also were unable to recommend the payment of a dividend on the ordinary shares. At their Lincoln works the extra cost for electric power and fuel alone amounted to £650 per week, or a total of £20,000, and they estimated that the total would not fall far short of £30,000. None of these charges could be passed on to the consumer. Railway rates, which were raised by 6½ per cent. in February last, were also of the gravest moment. The increase meant to the company an added burden of not less than £20,000 per annum.

Wills.

SUTHERLAND, S., Prestwick, Ayrshire, tube manufacturer	£13,274
TAYLOR, A. F., Sutton Coldfield, Warwick, machine tool maker	£6,420
RATCLIFF, T. C. S., of Lillington, Leamington, chairman of Charles Clifford & Son, Limited, brass founders, of Fazeley Street, Birmingham	£24,486
HAMPTON, J. A., of The Croft, Chantry Road, Moseley, Birmingham, managing director of Taylor and Farley, Limited, ironfounders	£24,751

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Surveying the general position of the Cleveland iron market at the moment, it must be admitted that the outlook is very far from satisfactory, and, in fact, completely justifies the pessimistic views freely expressed of late of any early improvement in the Tees-side industry. Competition from abroad, after a temporary weakening a few weeks ago, is again revived in an acute form, and imports of foreign pig-iron are now arriving in home ports on an increasing scale. It is even credibly reported that a Middlesbrough firm has recently negotiated for some 2,000 tons for early delivery, although possessing furnaces of their own in the district. Ironmasters claim that, with fuel prices at present levels, further price concessions are out of the question, and quotations consequently remain firmly fixed at previous rates, as follow:—No. 1 Cleveland foundry iron, 72s. 6d. per ton; No. 3 Cleveland G.M.B., 70s.; No. 4 foundry, 69s.; No. 4 forge, 68s. 6d. per ton, f.o.t. or f.o.b.

In the hematite section also business is again restricted in volume, in view of the limited requirements of British steelmakers, who are turning more and more to the use of basic iron for purposes for which at one time hematite was deemed essential. Current quotations are 77s. per ton for East Coast mixed numbers and 77s. 6d. for No. 1. On the North-West Coast Bessemer mixed numbers are quoted at £4 8s. per ton delivered at Glasgow, £4 12s. 6d. per ton delivered at Manchester, £4 14s. per ton delivered at Sheffield, and £4 15s. per ton delivered at Birmingham.

LANCASHIRE.—Consumers of foundry pig in this area are now only purchasing in restricted quantities, as is customary at this holiday period, prices ruling for both Staffordshire and Derbyshire at 77s. 6d. to 78s., delivered Manchester, or equal distance, Cleveland at 83s. 2d., Scottish at 96s., and hematites at 91s. 5d. to 92s.

THE MIDLANDS.—At Birmingham, for good quantities, Northants iron can be obtained at 65s. 6d., although the general quotation for small lots is still 65s. per ton. Derbyshire is quite firm at 70s. at the furnaces, and Staffordshire still varies between 68s. and 70s., according to the quantity.

SCOTLAND.—With the near approach of the Glasgow Fair holidays, business in the Scotch pig-iron market has further diminished, and the price is again easier at 78s. 6d. for No. 3 foundry, f.o.t. furnaces. Founders are taking very little interest in the market, and any iron bought is wanted immediately.

Steel.

In the Sheffield steel market business is on a declining scale, and billet users are of the opinion that shortly prices will be revised in order to attract buyers. There is, however, no alteration at the moment, acid open-hearth billets being £11 per ton, and hard basic £8 12s. 6d. per ton. Steel hoops are quoted £11 10s.,

Scrap.

Advices from the chief centres of the scrap metal trade indicate only a sluggish all-round demand, with prices mostly at slightly lower levels. In Scotland, machinery quality of cast-iron scrap is in slow inquiry, quoted at 72s. 6d. per ton—that is, for material in pieces not exceeding 1 cwt. Heavy ordinary cast-iron scrap to the same specification is being picked up freely around 67s. 6d. per ton, and old cast-iron railway chairs show no change around 73s. 6d. to 75s. per ton. Light cast-iron scrap is still 57s. 6d. to 60s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—As usually experienced in the mid-year period, buying in the market for standard copper has been reduced to very moderate limits, and, in the absence of an active consumptive demand at home and abroad, prices have developed further weakness. The statistical position, as disclosed in the following figures for May, was as follows:—Stocks in Metal Exchange warehouses in the U.K.—Refined, 3,162 tons; rough, 19,178 tons; total, 22,340 tons. In N. & S. America (refined), 96,499 tons; in N. & S. America (blister), 223,888 tons; in Havre, 5,781 tons.

Official closing prices of standard copper have been as follow :—

Cash: Thursday, £53 8s. 9d. to £53 10s.; Friday, £53 10s. to £53 11s. 3d.; Monday, £53 10s. to £53 11s. 3d.; Tuesday, £53 7s. 6d. to £53 8s. 9d.; Wednesday, £53 11s. 3d. to £53 12s. 6d.

Three Months: Thursday, £54 to £54 1s. 3d.; Friday, £54 1s. 3d. to £54 2s. 6d.; Monday, £54 to £54 1s. 3d.; Tuesday, £53 17s. 6d. to £53 18s. 9d.; Wednesday, £54 2s. 6d. to £54 3s. 9d.

Tin.—Movements in standard tin during the past week were mostly influenced by speculative interest, resulting in rather widely varied fluctuations in values, due in a measure to the very limited stocks of the metal available at present. It is estimated that the actual stocks of the metal in this country total about 750 tons, whereas at the end of May the stocks in the United Kingdom were approximately 1,700 tons.

Official closing prices of standard tin have been as under :—

Cash: Thursday, £300 to £300 5s.; Friday, £300 2s. 6d. to £300 5s.; Monday, £295 to £295 10s.; Tuesday, £291 to £291 5s.; Wednesday, £291 10s. to £291 15s.

Three Months: Thursday, £285 10s. to £285 15s.; Friday, £283 7s. 6d. to £283 10s.; Monday, £282 15s. to £283; Tuesday, £282 to £282 5s.; Wednesday, £282 15s. to £283.

Spelter.—Values of ordinary spelter have been fairly well maintained of late, and, in the absence of selling pressure, the market remains consistently steady. Consumption is moderately good; the price, moreover, is reasonably low, and, leaving little margin for further important decline, offers no incentive to sellers.

The following are the week's prices :—

Ordinary: Thursday, £28 2s. 6d.; Friday, £27 16s. 3d.; Monday, £27 16s. 3d.; Tuesday, £27 10s.; Wednesday, £27 16s. 3d.

Lead.—The market for soft foreign pig continues inactive and depressed, demand for home industrial purposes being still inadequate, with stocks tending to accumulate out of proportion to trade requirements. Consequently values are on the down grade, and are now at the lowest levels recorded since 1923.

The week's prices are appended :—

Soft foreign (prompt): Thursday, £23 10s.; Friday, £25; Monday, £23 2s. 6d.; Tuesday, £22 17s. 6d.; Wednesday, £23 6s. 3d.

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OF THE FINEST QUALITY
For Brass, Iron, Steel or Aluminium Castings.
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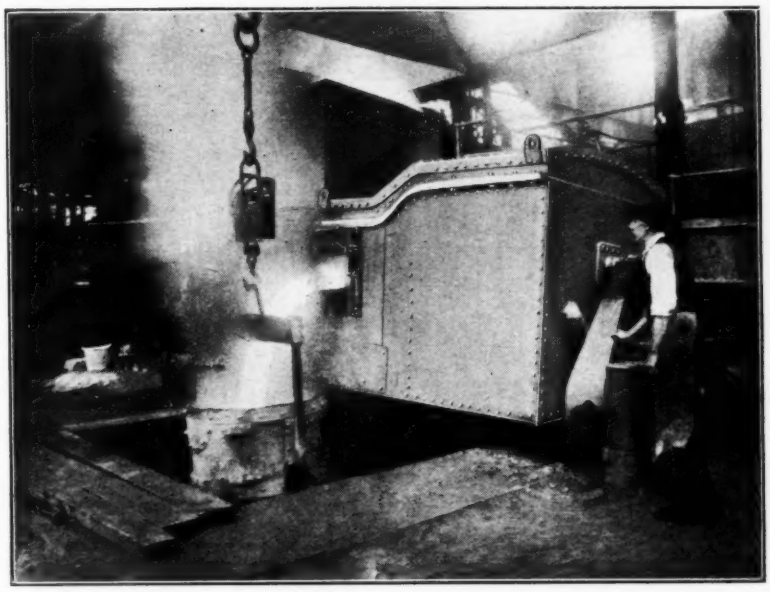

This photograph, taken in one of the large Steel Works in this country, shows our Patent Motor-Tilted Ferro-Manganese melting furnace in operation. Temperature generated in this Furnace 1,500°C.

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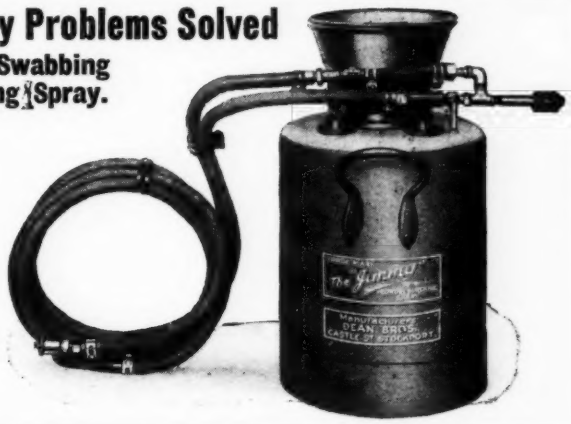

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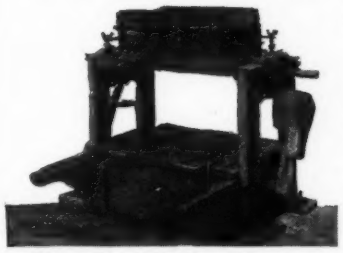

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Standard cash	53	11	3
Three months	54	2	6
Electrolytic	59	12	6
Tough	56	10	0
Best selected	57	5	0
Sheets	84	0	0
India	69	5	0
Wire bars	60	0	0
Do. July	59	15	0
Do. August	59	15	0
Ingot bars	59	15	0
H.C. wire rods	64	5	0
Off. av. cash, June 54	1	3	5/16
Do. 3 mths. June 54	13	9	5/16
Do., Sttlmnt. June 54	1	2	7/8
Do., Electro, June 60	1	1	1/2
Do., B.S., June 58	7	6	
Aver. spot price copper, June 54	1	3	1/4
Do., wire bars, June 60	4	7	3/4
Solid drawn tubes		12½d.	
Brazed tubes		12½d.	
Wire		9½d.	

BRASS.

Solid drawn tubes	11½d.
Brazed tubes	13½d.
Rods, drawn	10½d.
Rods, extd. or rlld.	7½d.
Sheets to 10 w.g.	9½d.
Wire	9½d.
Rolled metal	9½d.
Yellow metal rods	7¼d.
Do. 4 × 4 Squares	8d.
Do. 4 × 3 Sheets	8½d.

TIN.

	£	s.	d.
Standard cash	291	10	0
Three months	282	15	0
English	288	10	0
Bars	289	10	0
Straits	296	0	0
Australian	296	0	0
Eastern	289	5	0
Banca	300	0	0
Off.avr.cash, June 296	2	1	3/8
Do.,3 mths., June 286	10	10	
Do., Sttlmt. June 296	1	2	2/8
Aver. spot, June 296	2	1	3/4

SPELTER.

	£	s.	d.
Ordinary	27	16	3
Remelted	26	0	0
Hard	21	15	0
Electro 99.9	30	10	0
English	28	0	0
India	23	15	0
Zinc dust	37	0	0
Zinc ashes	10	0	0
Off. aver., June	28	12	1 5/16
Aver., spot, June	28	11	11½

LEAD.

	£	s.	d.
Soft foreign ppt.	23	6	3
English	24	10	0
Off. average, June	24	11	10½
Average spot, June	24	8	9

ZINC SHEET, &c.

	£	s.	d.
Zinc sheets, English	37	10	0
Do. V.M. ex whf.	35	0	0
Rods	42	0	0
Boiler plates	34	10	0
Battery plates	34	0	0

ANTIMONY.

	£	s.	d.
Special brands, Eng.	69	0	0
Chinese	53	0	0
Crude	39	0	0

QUICKSILVER.

	£	s.	d.
Quicksilver	21	15	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro-silicon—	
25%	£9 0 0
45/50%	£12 7 6
75%	£19 5 0
Ferro-vanadium—	
35/40%	14/3 lb. va.
Ferro-molybdenum—	
70/75% c. free	5/- lb.
Ferro-titanium—	
23/25% carbonless	11½d.
Ferro-phosphorus, 20/25%,	£17 15 0
Ferro-tungsten—	
80/85%, c. fr.	1/5 lb.
Tungsten metal powder—	
98/99%	1/8½ lb.
Ferro-chrome	
2/4% car.	£33 15 0
4/6% car.	£23 15 0
6/8% car.	£23 0 0
8/10% car.	£22 12 6
Ferro-chrome—	
Max. 2% car.	£36 10 0
Max. 1% car.	£42 5 0
Max.0.70% car.	£54 0 0
70%, carbonless	1/5 lb.
Nickel—99%, cubes or pellets	£170
Ferro-cobalt	9/3 lb.
Aluminium 98/99%	£105
Metallic Chromium—	
96/98%	3/3 lb.
Ferro-manganese (net)—	
76/80%, loose	£12 0 0
76/80%, packed	£13 0 0
76/80%, export	£11 15 0
Metallic manganese—	
94/96%, carbonless	1/10 lb.

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

Finished bars, 14% tungsten	s. d. 2 6
Finished bars, 18% tungsten	3 0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over	4d. lb.
Rounds and squares under ¼ in. to ¼ in.	3d. lb.
Do., under ¼ in. to 3/16 in.	1/- lb.
Flats, ¼ in. × ¼ in. to under 1 in. × ⅜ in.	3d. lb.
Do. under ½ in. × ¼ in.	1/- lb.
Bevels of approved sizes and sections	6d. lb.
Bars cut to length	10% extra.

Scrap from high-speed tool steel—

Scrap pieces	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales—						
Hvy. steel	3	2	6	to 3	3	0
Bundled steel & shrngs.	2	14	0	to 2	16	6
Mixed iron & steel	2	15	0	to 2	17	6
Heavy cast iron	3	3	6	to 3	5	0
Good machinery for foundries	3	5	0	to 3	7	6
Cleveland—						
Heavy steel	2	17	6			
Steel turnings	2	2	6			
Cast iron borings	2	1	0			
Heavy forge	3	15	0			
Bushelled scrap	3	5	0			
Cast-iron scrap	3	3	0	to 3	10	0
Lancashire—						
Cast-iron scrap	3	7	6	to 3	10	0
Hvy. wrought	3	2	6			
Steel turnings	2	0	0			
London — Merchants' buying prices delivered yard.						
Copper (clean)	48	0	0			
Brass (clean)	39	0	0			
Lead (less usual draft)	22	0	0			
Tea lead	18	0	0			
Zinc	19	0	0			
New aluminium cuttings	82	0	0			
Braziery copper	45	0	0			
Gunmetal	47	0	0			
Hollow pewter	180	0	0			
Shaped black pewter	140	0	0			

PIG-IRON

(f.o.t. unless otherwise stated).

N.E. Coast—	
Foundry No. 1	72/6
Foundry No. 3	70/-
Foundry No. 4	69/-
Forge No. 4	68/6
Hematite No. 1	77/6
Hematite M/Nos.	77/-
N.W. Coast—	
Hem. M/Nos. d/d Glas.	87/6
,, d/d Birm.	95/-
Midlands—	
Staffs. common*	—
,, No. 4 forge	—
,, No. 3 fdry.	68/- to 70/-
Shrops. basic	—
,, Cold blast, ord.*	—
,, ,, roll iron*	—
* d/d Birmingham.	
Northants forge	—
,, fdry. No. 3	62/6 to 65/-
Derbyshire forge	—
,, fdry. No. 3	70/-
,, basic	—
Scotland—	
Foundry No. 1	—
,, No. 3	78/6
Hem. M/Nos.	81/-
Sheffield (d/d district)—	
Derby forge	72/6
,, fdry. No. 3	74/6
Lincs. forge	—
,, fdry. No. 3	77/6
E.C. hematite	89/6
W.C. hematite	94/-
Lincs. (at furnaces)—	
Forge No. 4	—
Foundry No. 3	—
Basic	—
Lancashire (d/d eq. Man.)—	
Derby forge	—
,, fdry. No. 3	77/9
Northants foundry No. 3	—
Dalzell, No. 3	105/- to 110/-
Summerlee, No. 3	96/- to 102/6
Glengarnock, No. 3	96/- to 102/6
Gartsherrie, No. 3	96/- to 102/6
Monkland, No. 3	96/- to 102/6
Coltness, No. 3	96/- to 102/6
Shotts, No. 3	96/- to 102/6

FINISHED IRON & STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.) nom.	10	10	0	to 11	0	0
Angles					—	
Tees to 3 united ins.					—	
Nut and bolt iron					—	
Hoops			14	10	0	
Marked bars (Staffs.) f.o.t.			13	10	0	
Gas strip			12	10	0	
Bolts and nuts ¾ in. × 4 in.			15	5	0	
Steel—						
Ship plates	8	2	6	to 8	7	6
Boiler plts.			11	0	0	
Chequer plts.			10	5	0	
Angles			7	12	6	
Tees			8	12	6	
Joists			7	12	6	
Rounds and squares 3 in. to 5½ ins.			7	15	0	
Rounds under 3 in. to ⅜ in. (Untested)			8	0	0	and upwards
Flats, over 5 in. wide and up			9	2	6	
Flats, 5in. to 1½in.			8	2	6	
Rails, heavy			8	2	6	
Fishplates			12	10	0	
Hoops (Staffs.)			10	10	0	
Black sheets, 24g.			10	17	6	
Galv. cor. shts, 24g.			14	10	0	
Galv. fencing wire 8g. plain			12	10	0	
Billets, soft	6	10	0	to 7	0	0
Billets, hard					—	
Sheet bars			6	5	0	
Tin bars d/d			6	5	0	

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	2½
Sheet to 10 w.g.	1	2¾
Wire	1	3¼
Rods	1	2¾
Tubes	1	8
Castings	1	2

Delivery 3 cwt. free.

10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S.
Phosphor tin (5%) £30 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	per lb.
Ingots for raising	9d. to 1/3
Rolled—	
To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round—	
3/0 to 10 G.	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL

At Pittsburgh unless otherwise stated.

	Dols.
No. 2X foundry, Phila.	21.76
No. 2 foundry, Valley	18.00
No. 2 foundry, Birm.	18.00
Basic	20.75
Bessemer	20.76
Malleable	19.76
Grey forge	19.26
Ferro-mang. 80% d/d	90.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess billets	33.00
O.-h. billets	33.00
O.-h. sheet bars	33.50
Wire rods	42.00
	Cents.
Iron bars, Phila.	2.12
Steel bars	1.80
Tank plates	1.80
Beams, etc.	1.80
Skelp, grooved steel	1.80
Skelp, sheared steel	1.80
Steel hoops	2.30
Sheets, black, No. 24	3.00
Sheets, galv., No. 24	3.85
Sheets, blue an'l'd, 9 & 10	2.25
Wire nails	2.50
Plain wire	2.40
Barbed wire, galv.	3.20
Tinplate, 100 lb. box	$5.50

COKE (at ovens).

Welsh foundry	—
,, furnace	—
Durham & North.	
,, foundry	—
,, furnace	15/-
Other Districts, foundry	—
,, ,, furnace (basis)	12/- to 12/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20 × 14, box	18/10½
,,	28 × 20, ,,	37/9
,,	20 × 10, ,,	—
,,	18¾ × 14, ,,	—
C.W.	20 × 14, ,,	17/10½
,,	28 × 20, ,,	—
,,	20 × 10, ,,	—
,,	18¾ × 14, ,,	—

Terneplates 28 × 20, — per box basis f.o.b.

SWEDISH IRON.

Bars, hammered	£18/10 to £19/0
Rolled Ord.	£15/5/0 to £15/15
Nail rods	£15 12 6 to £16 0 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£8 to £12
Pig-iron	£6 0 0 to £6 10 0

all f.o.b. Gothenburg.

TUBES AND FITTINGS.

Up to and incl. 6 in.

	Tubes.	*Fittings*
Gas ..	67½% ..	45%
Water ..	62½% ..	40%
Steam ..	57½% ..	35%

W.I. 10% extra.

DAILY FLUCTUATIONS.

Standard Copper (Cash).

	£	s.	d.		
June 30	53	8	9	dec.	1/3
July 1	53	10	0	inc.	1/3
„ 4	53	10	0	No change	
„ 5	53	7	6	dec.	2/6
„ 6	53	11	3	inc.	3/9

Electrolytic Copper.

	£	s.	d.		
June 30	59	10	0	No change	
July 1	59	10	0	„	„
„ 4	59	10	0	„	„
„ 5	59	10	0	„	„
„ 6	59	12	6	inc.	2/6

Standard Tin (Cash).

	£	s.	d.		
June 30	300	0	0	inc.	45/-
July 1	300	2	6	„	2/6
„ 4	295	0	0	dec.	102/6
„ 5	291	0	0	„	80/-
„ 6	291	10	0	inc.	10/-

Tin (English ingots).

	£	s.	d.		
June 30	297	0	0	inc.	50/-
July 1	297	5	0	„	5/-
„ 4	291	10	0	dec.	115/-
„ 5	287	10	0	„	80/-
„ 6	288	10	0	inc.	20/-

Zinc Sheets (English).

	£	s.	d.		
June 30	38	0	0	No change	
July 1	37	10	0	dec.	10/-
„ 4	37	10	0	No change	
„ 5	37	10	0	„	„
„ 6	37	10	0	„	„

Spelter (ordinary).

	£	s.	d.		
June 30	28	2	6	dec.	5/-
July 1	27	16	3	„	6/3
„ 4	27	16	3	No change	
„ 5	27	10	0	dec.	6/3
„ 6	27	16	3	inc.	6/3

Lead (English).

	£	s.	d.		
June 30	25	0	0	dec.	10/-
July 1	25	0	0	No change	
„ 4	24	10	0	dec.	10/-
„ 5	24	5	0	„	5/-
„ 6	24	10	0	inc.	5/-

AVERAGE MONTHLY PRICES OF UNMARKED BARS (SOUTH STAFFS).

	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1897	6 0 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 0 0	6 0 0	6 3 9
1898	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 5 0	6 5 0	6 5 0	6 10 0	6 10 0	6 2 11
1899	6 10 0	6 15 0	6 15 0	6 15 0	7 0 0	7 0 0	7 10 0	7 10 0	8 10 0	9 0 0	9 0 0	9 10 0	7 12 11
1900	10 0 0	10 10 0	10 10 0	10 15 0	10 15 0	10 15 0	10 5 0	10 5 0	10 5 0	9 10 0	8 15 0	8 15 0	10 1 3
1901	8 0 0	7 10 0	7 5 0	7 0 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 15 0	6 17 11
1902	7 0 0	6 10 0	6 [illegible] 0	6 15 0	6 15 0	6 10 0	6 10 0	6 15 0	6 15 0	6 15 0	6 10 0	6 10 0	6 13 4
1903	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 7 0	6 5 0	6 9 4
1904	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 5 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 0 0	6 2 11
1905	6 5 0	6 5 0	6 0 0	5 17 6	5 15 0	5 15 0	5 15 0	5 15 0	6 0 0	6 5 0	6 15 0	6 15 0	6 1 10½
1906	7 0 0	7 5 0	7 5 0	7 5 0	6 17 6	6 15 0	6 12 6	6 10 0	6 10 0	6 12 6	6 16 3	7 3 9	6 17 8½
1907	7 3 9	7 5 0	7 [illegible] 0	7 5 0	7 5 0	7 7 6	7 5 0	7 7 6	7 7 6	7 7 6	7 7 6	7 5 0	7 5 11
1908	7 2 6	7 0 0	7 [illegible] 0	7 0 0	6 15 0	6 7 6	6 5 0	6 2 6	6 2 6	6 2 6	6 2 6	6 0 0	6 10 0
1909	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 0 0	6 0 0	5 17 6	6 0 0	6 2 6	6 2 6	5 17 6	5 19 9½
1910	6 2 6	6 3 4½	6 7 6	6 7 6	6 7 6	6 7 6	6 6 6	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 7
1911	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 5 0	6 10 0	6 12 6	6 16 6	6 7 0
1912	6 18 9	7 1 10	7 2 6	7 8 9	7 18 0	8 0 7	8 2 6	8 3 6	8 5 0	8 6 3	8 7 6	8 8 9	7 17 0
1913	8 11 6	8 [illegible]0 7½	8 10 0	8 8 1½	8 2 0	8 0 0	7 17 6	7 11 6	7 8 9	7 5 6	6 18 1½	6 17 6	7 16 9
1914	6 17 6	6 15 7½	6 12 6	6 10 0	6 10 0	6 10 0	6 10 0	7 11 10½	8 0 0	7 12 6	7 5 7½	7 6 3	7 1 0
1915	7 11 6	8 5 1	8 8 9	9 6 0	10 3 2	10 19 2	11 12 6	11 13 1½	11 13 9	11 14 3	12 1 10½	13 0 9	10 6 0
1916	13 7 6	13 16 8	13 12 9½	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 3 9½
1917	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0	13 15 0
1918	13 15 0	13 17 3	13 17 6	13 17 6	13 17 6	13 17 6	13 17 6	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 4 5½
1919	15 10 0	16 5 0	17 15 0	17 15 0	20 15 0	21 0 0	21 0 0	22 0 0	22 0 0	22 0 0	22 7 6	22 12 6	20 1 8
1920	24 7 6	24 10 0	25 10 0	27 10 0	29 5 0	31 0 0	31 10 0	31 10 0	31 10 0	31 10 0	31 10 0	29 7 6	29 1 8
1921	26 17 3	25 0 0	23 0 0	21 0 0	19 0 0	18 5 0	16 0 0	16 0 0	15 14 0	14 0 0	13 6 8	13 0 0	19 4 5
1922	13 0 0	12 3 9	11 14 0	11 11 10½	11 5 0	11 3 6	11 2 6	11 5 0	10 17 2½	10 16 3	10 13 0	10 12 6	11 7 0½
1923	10 16 10½	11 3 1½	12 2 6	12 8 9	12 11 6	12 1 3	11 15 11½	11 15 0	11 15 0	11 15 0	12 13 6	12 8 3	11 18 10½
1924	12 9 6	12 10 0	12 10 0	12 15 7½	12 17 6	12 17 6	12 17 6	12 17 6	12 17 6	12 14 0	12 12 6	12 12 6	12 14 3½
1925	12 12 6	12 12 6	12 12 6	12 12 6	12 12 6	12 7 6	12 7 6	12 7 6	12 4 6	11 18 6	11 13 9	11 13 0	12 6 2½
1926	11 7 9½	11 5 0	11 5 0	11 5 0	11 3 9	11 3 9	11 5 0	12 0 0	13 0 0	*	15 7 6	12 19 0	12 0 2
1927	12 6 3	12 2 6	11 14 0	11 0 0	10 18 9	10 13 6	—	—	—		—	—	—

* No quotations available owing to strike.

WILLIAM JACKS & COMPANY,

WINCHESTER HOUSE, OLD BROAD ST., LONDON. E.C.2.

18, BENNETTS HILL, BIRMINGHAM.

18, BENNETTS HILL, BIRMINGHAM.
11, OLD HALL STREET, LIVERPOOL.
ROYAL BLDS., FISHER ST., SWANSEA.
FOWLERS BUILDINGS, BOMBAY.
CLIVE STREET, CALCUTTA.
20, SECOND LINE BEACH, MADRAS.
1, HONG KONG ROAD, SHANGHAI.

REGISTERED TRADE MARK

OCEAN BUILDING, SINGAPORE.
JAVA STREET, KUALA LUMPUR.
5, SHAFFRAZ ROAD, RANGOON
NADIR HOUSE, MACLEOD ROAD, KARACHI.
1 SHAREH SONK EL TEWFIKIEH, CAIRO.

PIG IRON

SCOTCH, MIDDLESBRO', HEMATITE, BASIC, SPECIALS, &c.,

NON-FERROUS METALS

COPPER, TIN, LEAD, SPELTER, ANTIMONY, CHROME ORE

WILLIAM JACKS & COMPANY,

19, ST. VINCENT PLACE, GLASGOW.

ZETLAND ROAD MIDDLESBROUGH

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